AMERICAN MACHINIST

A JOURNAL FOR MACHINISTS, ENGINEERS, FOUNDERS, BOILER MAKERS, PATTERN MAKERS AND BLACKSMITHS.

VOL. 17, NO. 31. WEEKLY. | NEW YORK, THURSDAY, AUGUST 2, 1894. | $3.00 per Annum. SINGLE COPIES 6 CENTS.

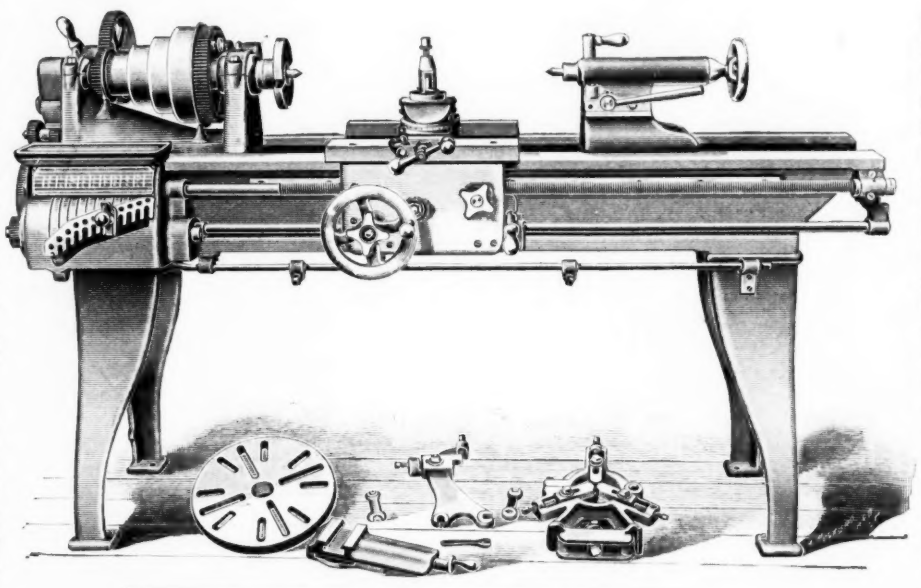
COPYRIGHT 1894, BY AMERICAN MACHINIST PUBLISHING COMPANY. **For Sale Everywhere by Newsdealers.** ENTERED AT POST OFFICE, NEW YORK, AS SECOND CLASS MATTER.

Improved Hendey-Norton Lathe.

The object of the accompanying illustration is to show a recent improvement in a lathe, which, since we first published illustrations of it (in our issue of March 23, 1893), has become one of the best known tools of its class both here and abroad, and has scored a distinct success.

Our readers who remember our reproduction of working drawings showing the construction and operation of the change-gear device, need be told nothing of its simplicity and substantial character, and it is sufficient to say that our good opinion of the lathe, founded upon an actual inspection and test of the first one built under working conditions, has been fully confirmed by the subsequent experience of others.

The improvement to which we refer is an automatic stop which stops the carriage either in feeding or screw-cutting and in either direction; the point of stoppage being so accurately maintained after being once set that work can be duplicated as to shoulders, and in internal screw-cutting, for instance, when the thread is chased up to a shoulder, it is not at all necessary to cut a groove at the bottom of the hole for the thread tool to run into, but only to set the stop for the required depth of thread; and, at every cut, the tool will stop at precisely the same place, and will, therefore, cut an annular groove at the end of the thread the shape of the tool and equal in depth to the thread cut. And as every machinist knows, this means relief from much anxiety on account of the danger of running into the work, spoiling it, or breaking the tool, and from the other alternative of stopping the lathe near the end of each cut and pulling the belt the rest of the way to the end.

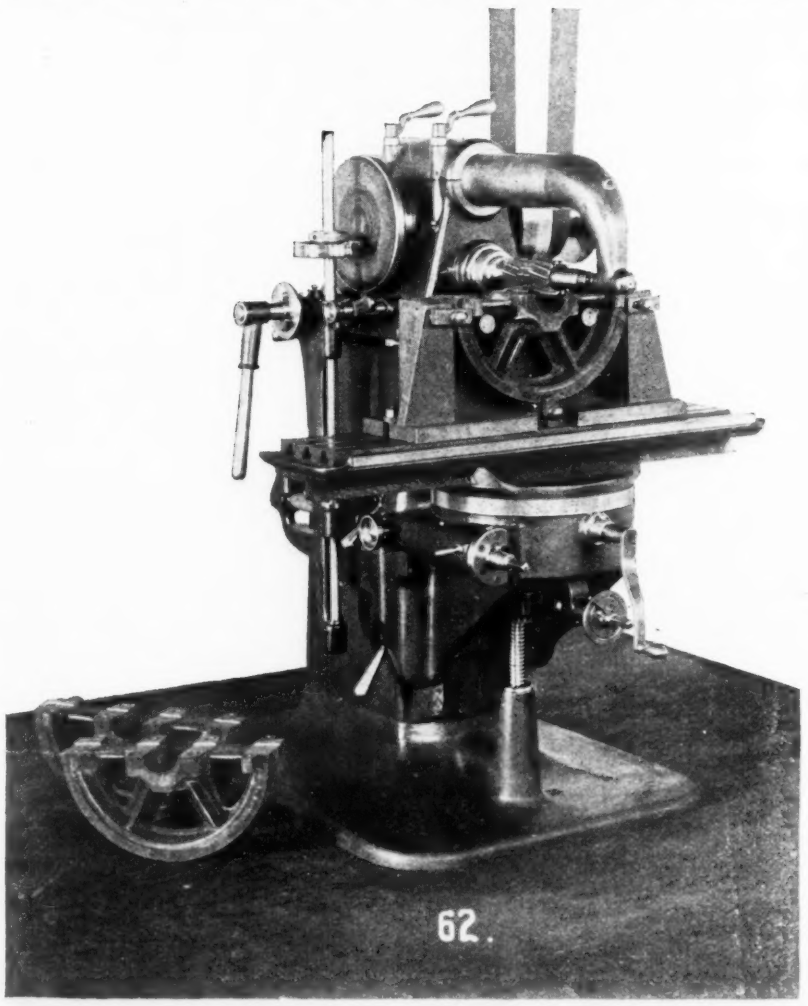


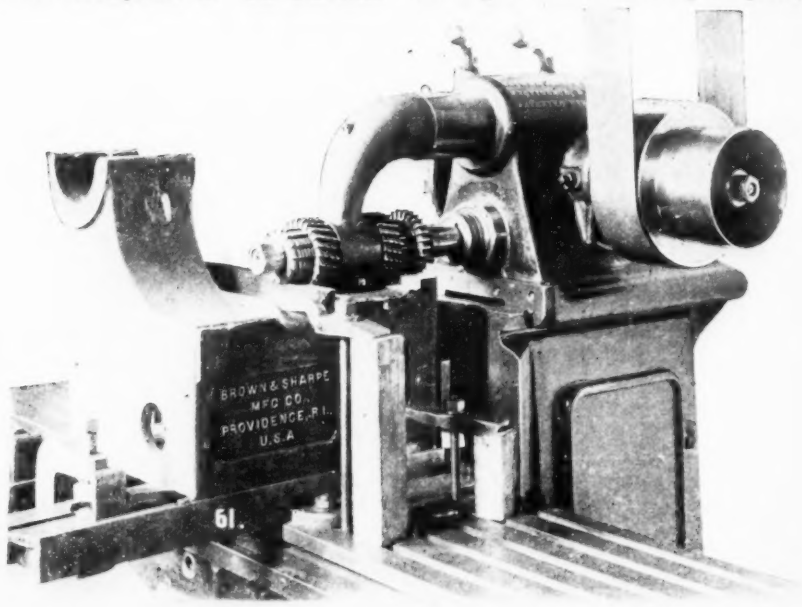
IMPROVED HENDEY-NORTON LATHE.

In working up to or from deep shoulders when cutting external threads it is also entirely practicable to run the lathe at full speed continuously until the job is finished, and, in one instance of a particularly bothersome job of this kind, it was found that three pieces could be threaded in one of these improved lathes in the time required to thread one in the old way.

It has been found in practice that users prefer to use the carriage reverse entirely in screw-cutting and thus leave the pulley and clutch on countershaft usually devoted to backing motion, free for use in an additional series of speeds, and the lathe has, therefore, in practice 16 spindle speeds, and in case of long screws, when it is desired to run the carriage back rapidly without opening the nut, the fast speed can be thrown in after reversing at the carriage.

The carriage of these lathes is now arranged so that any one of four different styles of rests may be put onto it, and these are made interchangeable so that the user may readily change from one to the other if he wishes. These rests are: The plain rest with shoe; a patented vertical elevating (by means of a screw); a new quick elevating rest, and a compound rest. When any one of the three last-named rests is chosen a plain rest accompanies it. The lathe illustrated is 14-inch swing with 8-foot bed, but the same improvements are now put upon all sizes. It is made by the Hendey Machine Co., Torrington, Conn.





MACHINE SHOP MILLING PRACTICE.

Machine Shop Milling Practice—XI.

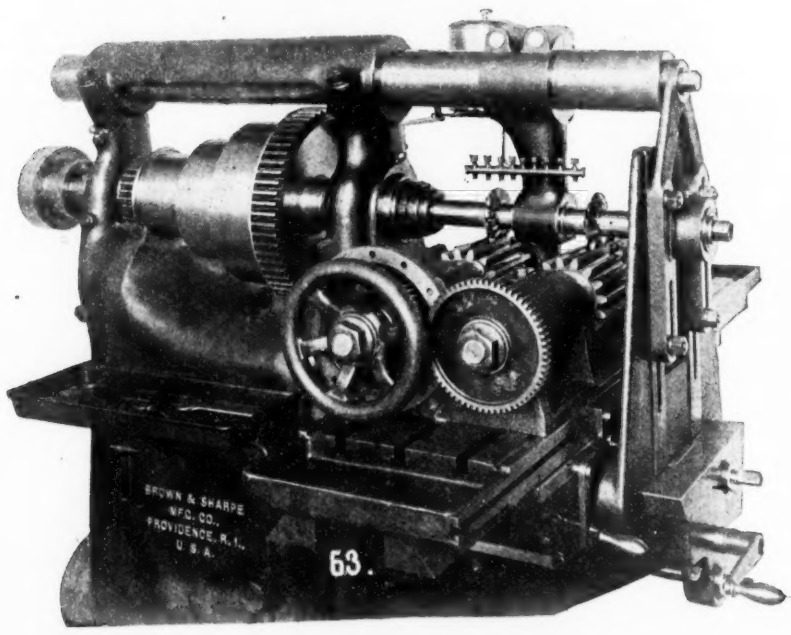
BY HORACE L. ARNOLD.

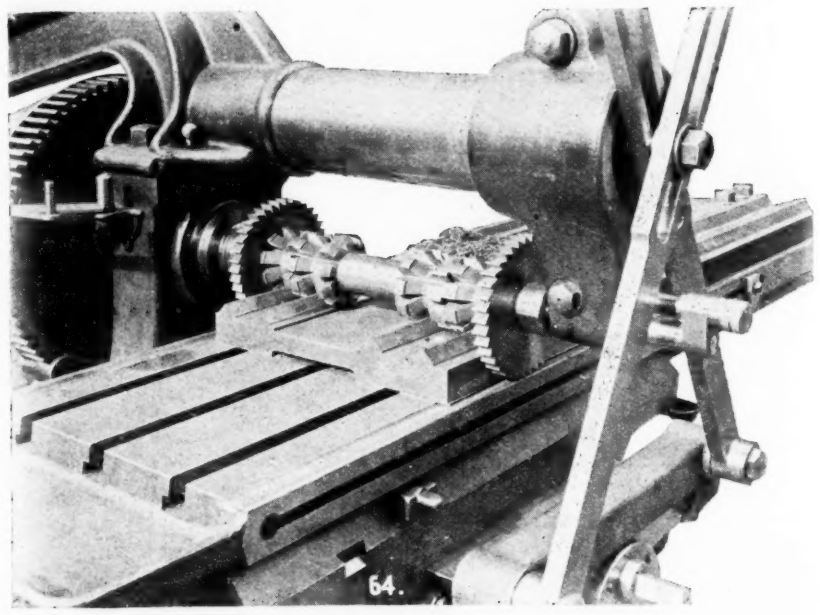
Fig. 61 shows a comparatively large piece in position on the table of the Brown & Sharpe No. 24 milling machine. The cut in this case, while too large to be made without the outboard mill arbor support, is too close to an upright member of the piece being worked to permit the use of the supporting arm outside of the mill arbor; the supporting arm is therefore used as an intermediate journal between two short gangs of mills which cover the faces of the double right-angle slide seat which are to be finished at one operation. This example is noticeable as showing the readiness with which the pillar and knee form of machine adapts itself to unusual forms of pieces to be operated upon. It is a common idea that to make milling economical the work must be specially designed with a view to finishing by milling. While there is no question that suitability of design for certain methods of finishing is in all cases a great element of cheap production, no matter what tools are to be used, or whether the operations are to be milling, boring, turning, slotting or planing, it is still evident from the illustrations given that the pillar and knee No. 24 with its large table and liberal vertical adjustment and efficient outboard support for the mill arbor, can readily take a great variety of cuts on variously shaped pieces which are not designed especially to suit this machine. This form of machine is in fact as nearly "universal" as can be obtained. The front of the machine is free, and the top of the work is fully exposed and open to inspection; and, granting the efficiency of the outboard brace there can be no question as to the entire fitness of the pillar and knee form of milling machine for general machine shop use.

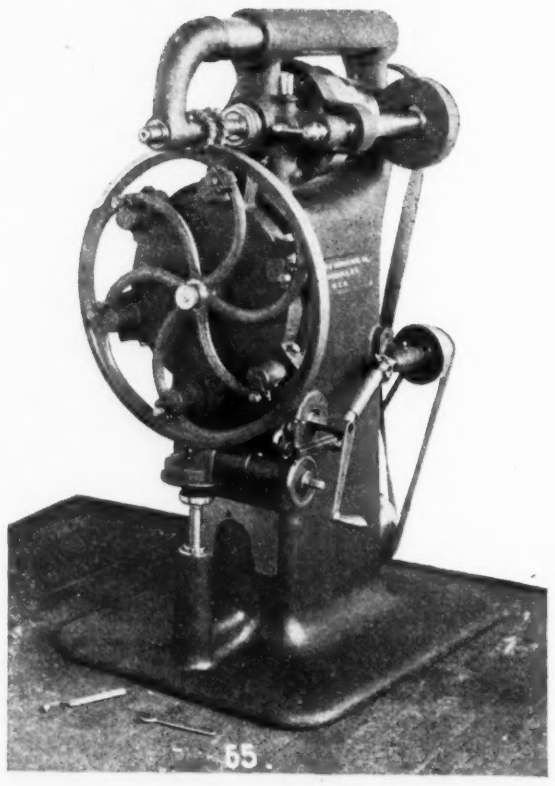
Fig. 62 shows the No. 24 with the work table mounted on worm gear rotated swivel or turn-table base, so that work placed on the table can have cuts made in it at different angles without moving the piece, and with half of a split gear blank held in position to have its flat milled for a tongue and groove joining with its mate. This illustration shows very clearly the extreme con-

venience of this form of machine for putting in and taking out work, and exhibits a solid, simple, well-designed fixture for supporting the split gear part.

Fig. 63 shows a companion for 62; it is another form of milling machine arranged as a duplex pinion cutter, arranged to cut two pinions in the same time commonly consumed in cutting one; the cutter arbor support is again particularly noticeable. Standard B. & S. gear cutters are used, and as the comparatively small holes in these cutters make a small cutter arbor necessary, the needful rigidity is given by the substantial arm support in the middle of the arbor between the two cutters, and the outboard support for both the mill arbor and the overhead supporting arm. The whole arrangement shows what can be done with a limiting condition at the outset. To make mills with large holes to take a stiff arbor would call for larger mills than is desirable; a long mill arbor must be had in some form if two pinions are to be cut at once, and extreme rigidity of mill support is essential to the correct sizing and smooth running of the pinions. The small cutters and small arbor are retained, and such support is given as to make the work produced answer every requirement, and this is done without the designing of a special machine for the purpose, without any marked change from elements in every day use in the Brown & Sharpe tools, and done in a manner to challenge the admiration of the most fastidious expert. I did not see this pinion cutter at work, but I have no doubt it could be driven with a feed of from 2 to 4 inches per minute, and that a pair of such steel pinions as are shown in the fixture could be easily cut in half an hour at an expense, all told, not exceeding 30 cents, or 15 cents each, or, say, about one cent per tooth, if made in such numbers as to keep the machine steadily employed.



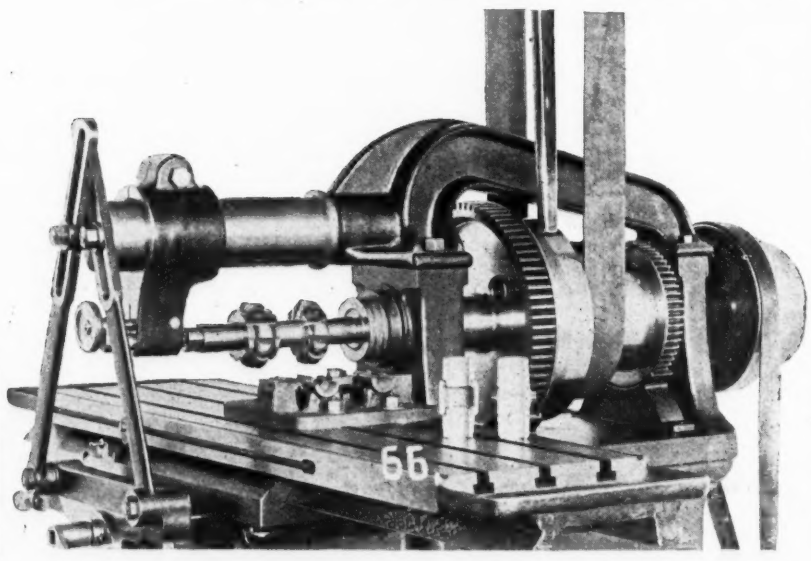




The wonderful cheapness with which cut gearing can now be produced will be further shown in the notice of the B. & S. automatic gear cutter. Indeed, I have no doubt that cut gears can be made and put in place for less money, in ordinary small machine sizes, than it costs to put *good* cast gears of the same size in place and do even the same job would require a very skillful workman to bring the piece out in any kind of form no matter how much time was taken.

Fig. 65 shows another most efficient factor in the production of cheap gearing, by which the rim of a gear blank, face and edges, is finished at one operation, true to size, in the most perfect manner, and the location of the rim and hub with relation to each other made absolutely unvarying. It will be observed that every one of the six slender arms is held in a self-adjusting "poppet" clamp, these clamps being arranged to slide in and out and turn round and secured by screws against the shanks, so that the hub of the wheel may be first clamped in place, and then each arm may be rigidly secured to the revolving plate without in any way distorting the slender structure of the wheel. Here, again, rapidity of production and accuracy of result are most happily assured by simple means, and in a most elegant structure, and the comparison between milling and lathe work on this job shows what great advantages may be gained by milling in a large and most important line of operations which are now almost universally performed in the lathe, with single pointed tools. It is true that in the past few years special forms of the lathe making several cuts at once have met with a deservedly great success, but these tools require a very stiff wheel for rapid finishing, and would not show to advantage on work of the character exhibited in Fig. 65. Mitre and bevel gears are also finished in blank on this machine with great rapidity, and, of course, with perfect accuracy.

Previous mention has been made in these articles of the great economy with which all descriptions of boxes are fitted for their seats by the use of the milling machine, especially such as are flanged, like lathe headstock boxes and strap connecting-rod brasses. In Fig. 66 a pair of mills are shown with a fixture holding the mating halves of a pair of hanger boxes, of which the B. & S. Co., of course, use a great number. These mills do not surface the outside of the boxes, those surfaces being left rough, but cut the semi circular insides or bearing surfaces, and the rabbet shoulders; the mills are so accurately formed that after the boxes are screwed together it is only needful to pass a hand reamer through the shaft seat to make a perfect job; the end of the boxes may, of course, be readily squared off by pin-milling, after the box is otherwise completed, at cost of, perhaps, one eighth of the expense of planing the two halves to fit each other, and afterward chucking the holes and squaring the ends on an arbor in what would be considered the best manner in a shop which did not include milling among its machine shop operations.



I have given these numerous examples of simple operations and fixtures from the Brown & Sharpe shop practice not to advertise the Brown & Sharpe products, but for the particular reason that in the Brown & Sharpe shops, more than in any other within my knowledge, the milling machine is used as a general every-day factor in machine shop work. It is not alone in special cuts, and in finishing surfaces which require special cutters made for each particular piece, that the Brown & Sharpe shops use milling machines. Such a cut as is shown in Fig. 61 can be made by an assemblage of plain flat mills of different diameters, which can be made up without loss of time from stock mills; the same is true of the mills shown in Figs. 62, 64 and 65, the V-mills shown in 64 being, of course, standard angles. It is also true that to apply milling to the finishing of comparatively small lots of pieces of constantly varying shapes requires a large stock of costly tools with the needful men and appliances to keep them in perfect order, ready for instant service, and that in many cases special fixtures are also needed to hold the work. But in the face of this drawback of more expense for plant and more tool-room facilities stands the broad undeniable fact of superior production as to finish and uniformity at a small fraction of the time expenditure needed by the lathe and planer for the same work.

An inspection of the Brown & Sharpe shop will convince any intelligent mechanic of the economy of milling machine work, and it is to give the many machinists who are not so situated as to readily inspect the establishment at Providence that I give these extended illustrative examples of the every-day practice there.

The twelve-inch gun seems to be a veritable terror to the maker of armor plates. Recently it sent a shot, at a very moderate velocity, through an eighteen inch plate of the Carnegie lot, and through a large quantity of backing, without a great deal of damage to the shot. The plate was thought to have been "treated" in a very superior manner, but after yielding so easily to the shot it was thought to have been soft.

It is said that the Russian Government has perfected a shell for large guns that has greater penetrating powers than any yet devised. The manner of treating the shells is kept secret.

Economical Steam Compression.

BY M. E.

During the last few months two contributions have been made to steam engine literature dealing with compression in engine cylinders. The first of these,* by Frank H. Ball, is chiefly devoted to the enunciation of a theory regarding the relations which the author thinks should exist between the expansion curve and the compression curve, "so that for any given point of cut off the point of exhaust closure corresponding in efficiency may be known by inference."

In the second paper,† Prof. J. Burkitt Webb gives a graphic method of determining the most economical degree of compression in a given indicator card, and at the same time comments somewhat adversely upon Professor Cotterill's mathematical treatment of the problem. In what follows I shall endeavor to show that the mathematical method referred to is not very formidable, but before doing so something may, with advantage, be done to set forth the point at issue in a plainer and simpler manner than has been done by either of the authors of the above mentioned papers.

In Professor Rankine's masterly treatise on the "Steam Engine," first published in 1859, it is stated that the most advantageous adjustment of the compression is that "which takes place when the quantity of steam confined 'or cushioned' is just sufficient *to fill the clearance at the initial pressure.*" He further states in effect, that with the compression thus adjusted the efficiency of the steam is undiminished by combined clearance and compression.

Bearing the sign manual of Rankine, it is not surprising that this theory should have remained unchallenged for a number of years. So far as I am able to ascertain, the first to dispute the accuracy of Rankine's conclusions was Mr. J. MacFarlane Gray, who, in a paper on the subject read before the British Institute of Naval Architects in 1874, says: "Having had occasion to doubt this (Rankine's) statement, I have looked into the question and I find it is not the case; the amount of compression given above is never the best adjustment, and there is no adjustment possible whereby the steam efficiency will not be impaired by the effect of clearance." It may be thought from this that it is now somewhat late in the day to commence an "attack"—as Mr. Ball calls it—upon the full compression theory; but I have found many who still steadfastly believe in it, so I judge that a brief review of the subject may not be out of place at the present.

Right here it should be stated that Mac Farlane Gray's statement requires some qualification, inasmuch as it is possible—theoretically, at *least*—for the efficiency of the steam, under certain conditions, to remain unimpaired by the combined effects of clearance and compression. This will be seen to be so from the following considerations: In Fig 1, let $B\ E$ represent the working stroke of a cylinder and $B\ F$ the clearance length. The volume of steam in the cylinder when the cut-off point C is reached—and which is represented by the length of the abscissa $D\ C$—subsequently expands, the pressure falling from $H\ A$ to $G\ E$. In the present case, the back pressure is taken equal to the terminal pressure, so that the work done by the steam is represented by the area $A\ C\ E\ B\ A$. Assuming for simplicity that steam is cut off at 25 per cent. of the working stroke $E\ B$ and that the clearance $B\ F = 5$ per cent. of the piston stroke, we shall have a nominal ratio of expansion of 4 and a real ratio of $\frac{105}{30} = 3.5$, with an initial pressure of 100 pounds, the terminal pressure $G\ E$ will, therefore, be $\frac{100}{3\ 5} = 28\ 57$ pounds.

If, now, the exhaust is closed at M so that sufficient steam is compressed to fill the clearance at the end of the stroke with steam of initial pressure, the work area of the diagram will be reduced by the area $A\ M\ B$. But the steam consumption is now $C\ A$ instead of $C\ D$, or $\frac{25}{105}$ instead of $\frac{30}{105}$ of the whole cylinder volume. Assuming hyperbolic expansion and compression (which will be taken throughout for simplicity) it is clear that $\frac{M\ B}{B\ F} = \frac{E\ K}{K\ F}$, or that the ratio of compression is equal to the real ratio of expansion, and therefore $M\ B$ the period of compression $5 \times 2.5 = 12.5$ per cent. of the working stroke $E\ B$.

Supposing, next, the clearance to no longer exist. We shall then have the steam consumption represented by $C\ A$ as with clearance and full compression, but the work area of the diagram will now be $A\ C\ m\ B\ A$ if expansion is carried down to the same back pressure (28 57 pounds) as before. The length $E\ m$ will be $= 100 - \frac{100 \times 25}{28.57} = 12.5$ per cent. of the working

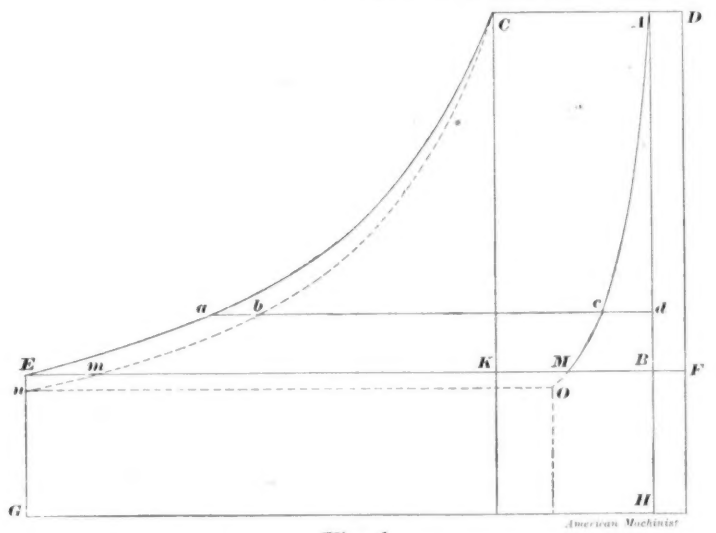


Fig. 1

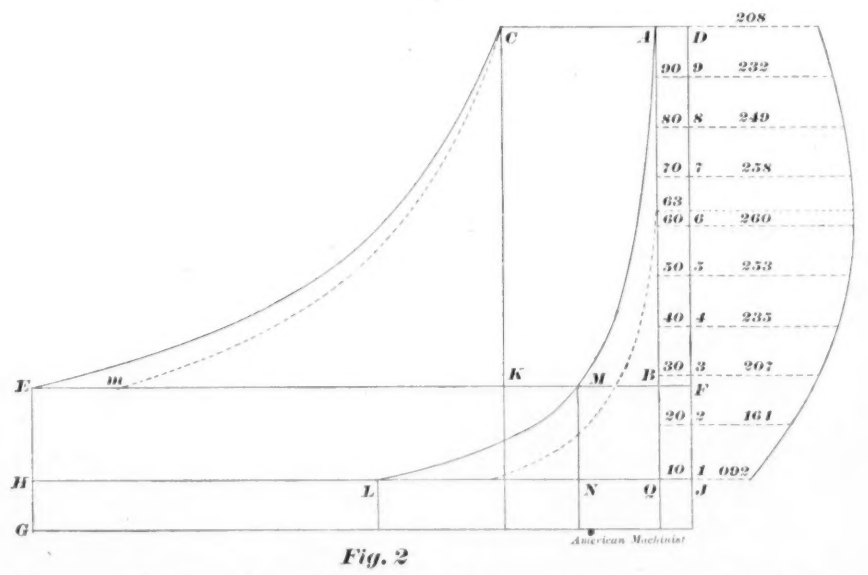


Fig. 2

stroke or precisely equal to $M\ B$, as just found. Similarly, any other intercepted portion of any abscissa, as $a\ b$ and $c\ d$, will be found equal to each other, from which it follows that the whole area $C\ E\ m =$ the whole area $A\ M\ B$. In other words, the work done in compressing the clearance steam up to the initial is exactly compensated by the expansion work performed in the return stroke by the steam thus compressed. The steam consumption being the same in both cases, it follows that the same amount of work is done by the same amount of steam, whether there is clearance and full compression or no clearance and no compression, *provided* that in the first case the expansion is carried on until the terminal pressure is equal to the back pressure, and that in the second case the steam is expanded down to the *same back pressure.*

While these conclusions are of considerable theoretic interest, it is desirable to point out that in practice no such comparison could be made in *one and the same cylinder*, since the expansion in the non clearance case would continue beyond m, reaching n at the end of the stroke. Then if the back pressure $E\ G$ was established by outside influences, the negative loop $m\ n\ E$ would be formed and its area would need to be deducted from the area $C\ m\ M\ A$. On the other hand, if the terminal pressure of the expanding steam is to determine the back pressure, then the area of the diagram will be augmented by that inclosed by the lines $m\ n\ O\ M\ m$.

We have now to examine how these conclusions are affected by free expansion, "drop" or fall of pressure at the termination of the expansion stroke. In Fig. 2 the former diagram is reproduced, but at the end of the stroke there is a fall of pressure from $G\ E$ to $G\ H$ and $H\ J$ is therefore the back-pressure line. To completely fill the clearance space with steam at initial pressure, exhaust closure must take place at L, found by prolonging the hyperbola $A\ M$ until it meets the back-pressure line. The work expended in compressing the exhaust steam is now represented by the much increased area $L\ M\ A\ Q$ which, as will be readily perceived, constitutes a much larger proportion of the whole area $A\ C\ E\ H\ Q$ than $A\ M\ B$ does of $A\ C\ E\ B$ in the first diagram. As the consumption of steam is the same in both cases, it follows that with clearance and compression a loss of steam efficiency results, if free expansion occurs at the end of the steam stroke.

Examining this matter more in detail, it is first seen that the expansive energy of the clearance steam takes effect only down to the terminal pressure line $E\ F$, being represented by the area $C\ E\ m$. On the other hand, steam of the back pressure $G\ H$ requires to have an extra amount of work expended upon it to first compress it up to the terminal pressure $G\ E$, which work is represented by the area $L\ M\ N$. The arrangement also involves the performance of work represented by the area $M\ B\ Q\ N$, which in the first case formed part of the inevitable back-pressure work. It is clear that the total waste work area $L\ M\ B\ Q\ L$ will be greater, the greater the ratio of the back pressure to the terminal and that with a late cut off and a low back pressure it may become almost out of all proportion greater than the small amount of work restored during the expansion of the steam stroke. It now remains to show that some other compression period less than $L\ Q$ will give a greater steam efficiency by increasing the effective area of the diagram, even although this entails the use of an increased quantity of steam per stroke. In the present case we will proceed to do this by the most practical method—by determining the mean effective pressure with several various degrees of compression, setting against each the quantity of steam used per stroke. In what follows:

P_1 = initial pressure; P_2, terminal pressure; P_3, back pressure; P_m, the actual mean forward pressure; P_b, the mean back pressure; r', the apparent, and r the real ratios of expansion; R, the ratio of compression, and c, the clearance expressed as a fraction of the piston displacement or working stroke. As before, in Fig. 2, $P_1 = 100$ pounds; $P_2 = 28.57$, while P_3 is taken at 10 pounds per square inch. The working stroke $E\ B$ is taken as unity; $r' = 4$; $r = 3.5$ and $c = .05$.

The mean forward pressure which would obtain if the clearance formed part of the working stroke is $p = P_1 \left(\frac{1 + \text{hyp. log. } 3.5}{3.5}\right) = 64.36$ pounds.

The actual mean forward pressure $P_m = p\ (1 + c) - c\ P_1 = 62.58$ pounds.

The mean back pressure with full compression and therefore with $R = 10$ is $P_b = P_3\ (1 + c - c\ R + c\ R \text{ hyp. log. } R) = 17.01$ pounds.

In columns 1 and 2 of the accompanying table the values are given of the back pressures corresponding to the various values of R from 10 to 1.

TABLE.

(1) R	(2) P_b	(3) $P_m - P_b$ = M. E. P.	(4) Steam Used. Volume at Terminal Pressure.	(5) Steam Efficiency Factor.
10	17.01	45.57	87.50	.5208
9	15.88	46.70	89.25	.5232
8	14.81	47.77	91.00	.5249
7	13.81	48.77	92.75	.5258
6	12.87	49.70	94.50	.5260
5	12.02	50.56	96.25	.5253
4	11.27	51.31	98.00	.5235
3	10.64	51.94	99.75	.5207
2	10.13	52.39	101.50	.5161
1	10.00	52.58	103.25	.5092

In the third column the resulting mean effective pressures are given, while in column (4) the corresponding amounts of steam consumed are tabulated. It should be explained that these latter are, for convenience, in percentages of the length of the working stroke, reduced to the terminal pressure $G\ E$, Fig. 2, of 28.57 pounds. With a back pressure P_3 of 10 pounds, the steam used in percentage of the working stroke and expressed in this manner is $105 - 1.75\ R$.

Finally, by dividing the respective mean effective pressures by the corresponding steam consumptions, we obtain what I have called a series of steam efficiency factors. These which are given in column (5) show very conclusively that complete or full compression is not by any means the most economical. As will be seen, the efficiency factor increases as the ratio of compression decreases until for some value of R between 7 and 6, it reaches its maximum. After this point is passed the efficiency diminishes, falling more rapidly as R approaches unity. This variation of the efficiency factor will be best appreciated by inspecting the curve which I have drawn in Fig. 2, and in which the lengths of the successive abscissæ represent the values of the efficiency factors of the corresponding compression pressures, $D\ J$ being taken as a base = .50. From this it will be seen that for a ratio of compression of 3 *the efficiency is practically the same as with full compression*, and that these ratios are materially less than those which gives maximum efficiency, which, it will be perceived, calls for a compression ratio somewhat greater than 6. By subdividing the division 6—7, it is readily found that the efficiency reaches its maximum when $R = 6.3$, or that under the particular conditions assumed the most advantageous pressure to which to compress the clearance steam, is 63 pounds.

The foregoing method of treating the subject, while exposing the fallacy of the

* "Compression as a Factor in Steam Engine Economy." A paper read before the American Society of Mechanical Engineers (AMERICAN MACHINIST, Aug. 24, '93).

† "Economical Steam Compression." A paper read before the American Association for the Advancement of Science (AMERICAN MACHINIST, January 11, 1894)

"complete compression" theory and exhibiting the question generally in a practical manner, is, however, much too cumbersome for ordinary use. Solutions of the problem have been submitted by various writers, the graphic construction of Professor Webb, previously referred to, being apparently one of the simplest, while the mathematical solution by Professor Cotterill is generally regarded as one of the most complex. First impressions are in this case, however, somewhat misleading. In the graphic method some difficulty is experienced in endeavoring to cut up the diagram as required, more especially if no planimeter is available. It is also necessary to draw an extension of the expansion curve, which operation takes time. On the other hand, Professor Cotterill's expression is somewhat appalling at first sight. Using the same notation as above he gives the following formula by which to determine the most economical ratio of compression:

$$\log._e R = \log._e r + 1 - \frac{r\,P_3}{P_1} - \frac{c\,r}{1+c}\left(1 - \frac{R\,P_3}{P_1}\right).$$

Much of the difficulty is, however, more apparent than real. Thus filling in the values for the foregoing example, we have

$$\log._e R = 2.2528 - .35 - \frac{.175}{1.05}(1 - .1\,R),$$

$$= 1.736 + .0166\,R,$$

and by trying a few values it is soon found that $R = 6.3$. It is more convenient in practice to give the point in the return stroke at which compression should commence. If X be the fraction of the return stroke at which compression should commence

$X = 1 + c - c\,R$, so that in the case under notice

$X = 1.05 - .315 = .735$ or 73.5 per cent.

It will be seen from this that Cotterill's formula improves on acquaintance, but at the same time, a more simple expression, if obtainable, is very desirable. I therefore submit the following method by which the calculation of a series of values of X can be readily effected, the results being practically identical with those obtained by separate calculation by Cotterill's formula.

In the diagram, Fig. 3, the base is taken to represent the ratio in per cent. of back to initial pressure or $\frac{P_3}{P_1}$, commencing at 5 per cent. The horizontals, read on the right-hand scale, give values of X, and the several sloping lines, read on the left hand scale, a series of actual percentages of steam admission

$$\left(= \frac{\text{nominal admission} + \text{clearance}}{\text{working stroke} + \text{clearance}}\right).$$

The clearance is taken at 5 per cent., as before.

Referring to the lowest sloping line, for example, we first calculate by Cotterill's formula, the value of X for $\frac{P_3}{P_1} = .05$; $r = 6.66$ and $c = .05$. This will be found to give $X = 48.3$, locating the point a. Similarly, the position of the point b can be determined. By calculating a series of intermediate values of X I have found that they lie almost *exactly upon the straight line a b*, so that once the extreme values are determined, all the intermediate ones can be at once read off. Within the limits shown in the diagram, this rule applies to any cut-off, and, as will be seen, it fortunately happens to fulfill all the probable requirements of practice. The rule does not cease to apply, in one direction until $\frac{P_3}{P_1}$ becomes less than 5 per cent., while for high ratios of expansion it may be used to the full limit in the other direction. Thus, in the diagram the line $a\,b$ is carried on until P_3 equals the terminal pressure, and its ratio to the initial becomes 15 per cent. The other lines are successively extended by about five divisions horizontally for ten vertically. It should be said that the results obtained by this method, within the limits imposed, seldom differ by more than one per cent. from the calculated values. Similar diagrams for other clearances, etc., may be readily constructed in this manner, and then a whole series of intermediate results can be read off without calculation of any kind whatever. If desired, however, they may be calculated by the simple straight line equation. Thus, for a real expansion ratio of 2.5, with 5 per cent. clearance, within the limits indicated, the percentage of the stroke to be completed before compression commences, is given very approximately by the expression:

$$X = 75 + 5\,\frac{P_3}{P_1} \text{ per cent.}$$

Of course, in many cases, considerations other than the securing of maximum steam efficiency decide the amount of compression to be employed. It should also be remarked that no allowance is here made for the effects of cylinder condensation alluded to by Professor Webb. Still, when divested of these complicating considerations, the mechanical aspect of the question as above reviewed is an interesting one for the progressive steam engineer, and, as before stated, it is a matter upon which much misconception still exists.

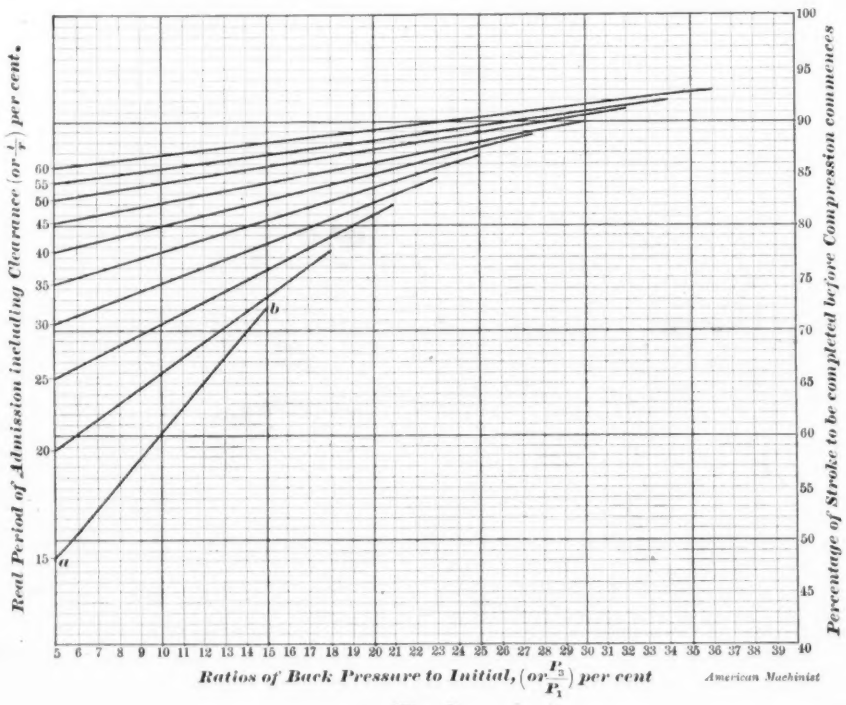

Real Period of Admission including Clearance (or $\frac{1}{r}$) per cent.
Percentage of Stroke to be completed before Compression commences
Ratios of Back Pressure to Initial, (or $\frac{P_3}{P_1}$) per cent
a
b
American Machinist

Fig. 3

Economical Steam Compression.

LETTERS FROM PRACTICAL MEN.

Draftsmen and Their Work.

Editor American Machinist:

Regarding "Bell Crank's" remarks on "Draftsmen and Their Work," June 21st issue, would say I do not feel the weight of the "massive store of knowledge" it would seem to require to write on the above subject, but there are some points I would mention in this connection.

Rule 1, as stated by him, is real good, and I wish it could be enforced, if such a thing were possible. I would add to it, however, that the views should stand the same as if the drawing paper were transparent, and it had been folded down over the object which is seen through it.

Rule 3, as stated, I should in general take exception to; it says. "All dimensions to be in inches up to 36 inches, and in feet and inches above that size." This may be good practice in his shop, but I can think of but one case in which I should consider it so, and that may be "Mr. Bell Crank's," viz., nearly all the measures on drawing are small, and would come in inches, anyway, in which case it would tend to avoid confusion to have them all so, and if there were but few longer than two feet, should make them in inches also. I do not think any limit could be applied to this distance. In boiler work they speak of the diameter of the shell in inches for sizes to and above 36 when it does not come out in even feet, and sometimes when it does do so, and 6 feet seems to be the point to change at when speaking of sizes of locomotive driving wheels. While, on the other hand, if most of the measures were in feet and inches, I should, I think, make them all so, to as small a distance as two feet in ordinary cases, and if but few were shorter than two feet, should make them in feet and inches also, to conform to the general style, and to lead to less confusion in reading. 1′ 3″ is no more likely to be read 13″ than 3′ 5″ is to be read 35″. I have mentioned two feet as the more convenient changing point, because rules and squares are usually 2 feet, or 24 inches long, and are figured from 1 to 24, making it natural even for a person to state a distance thus, 8 feet and 19 inches, which, considering the ordinary rules in use, is easier than to call it 9 feet 7 inches, and less liable to mistakes, for it saves two mental transpositions, and by two different men. If 3-foot rules were in common use, I should take no exception to Rule 3.

After all has been said, however, it seems to me better to follow the established practice of any good shop, even though it may not meet our ideal exactly, than to cause a liability to confusion and mistakes by introducing some new ideal system to replace one that serves its purpose well, and the men are used to, which has no vital fault.

I notice also what seems to me a fault in the graduation of many drawing scales, most noticeable when the graduation is fine, viz., the short lines are too long, or, in other words, run on too far, for in reading any rule the distance is always found by the inside ends of the lines, and then the proper division is followed down to the edge and then set off. Thus, the longer the short lines are the more confusing and liable to get on the wrong one, this becomes.

Under Rule 7, would say the division line in fractions should *always* be horizontal for shop use. When made slanting I have seen $1\frac{1}{16}$ inches so written that it was easily read $1\frac{1}{16}$ inch, but drawings *should not* be made like a labyrinth puzzle.

C. S. Beach.

Removing a Piston Head.

Editor American Machinist:

The article in issue of June 28th, by Mr. F. N. Taylor, entitled "Removing a Crank Disk," and the editor's comment on same, prompts the writer to relate an experience had in removing a 42 inch piston from its rod.

A 42x84x60 vertical blowing engine was disabled by accident, and to effect the necessary repairs the pistons and rod had to be taken out of the engine. The design of the machine was such that the rod could not be taken out without removing the lower or steam piston head.

All of the usual means for detaching or removing the head from the rod were tried, such as the free use of sledges and heavy rams, and then a heavy iron strap was rigged around the head; a hydraulic jack was suspended in such a manner as to push against the end of the piston rod, but it refused to move, even with quite a hot fire burning on the head. As a last resort previous to breaking the head off, the following was tried with success: A $\frac{7}{8}$ inch hole was drilled into the end of the rod for a depth equal to the thickness of the head. A round disk of wrought iron about 4 inches in diameter, by about $1\frac{1}{2}$ inches thick, was made, faced off true and smooth on both sides. Into one of the faces of this disk was drilled two holes about $\frac{7}{16}$ inch diameter and about two thirds of the way through the disk, a little care being taken to get the two holes close together. Then into the edge of the disk were drilled two more holes, in such a manner that they would communicate with the two holes drilled in the face of the disk. One of the holes in the face and both holes in the edge of the disk were tapped for pipe connections. Into the tapped hole in the face of the disk was screwed a piece of pipe of a length some little less than the depth of the $\frac{7}{8}$ inch hole in the end of the rod. Then a circular piece of sheet copper about 4 inches in diameter with a one-inch hole was prepared. Then the iron disk with its protruding pipe was placed against the end of the piston rod, with the pipe inserted in the hole in the end of the piston rod, the copper washer placed between the disk and end of piston rod so as to form a gasket. The hydraulic jack was again brought into use in such a manner as to force the disk against the end of the piston rod. Pipe connections were then made to the two holes in the edges of the disk—one for the admission of water under pressure, the other to carry off the overflow. A charcoal fire was again made on the piston head, and when the head was quite hot a strain was put on the hydraulic jack, with the result of forcing the rod out of the head.

Almon Emrie.

A Neglected Study.

Editor American Machinist:

You would have to look carefully to find any branch of study that is of so great importance to every human being, and that is so sadly neglected, as natural philosophy.

Perhaps in the higher branches sufficient notice is taken of it, in some cases, but why should it not be a common-school study as well as geography? Is it not of as great importance to know a little about the action, and the reasons of action, in nature before our eyes every day of our lives, as to know that the world is round, and that people have sailed around it? There are thousands of simple things taught by natural philosophy that can be made good use of by common people, and would be made good use of, if they were only known.

Just imagine, or suppose, that fishes possessed human intelligence, and that for thousands of years, and up to date, they were not aware that they were living in a fluid and under pressure; but this is exactly the case with millions of commonly considered intelligent people to day. They do not know that they are living in an atmosphere of air in exactly the same way as a fish lives in his atmosphere of water, and under pressure as well.

When such a thing is known, as it should be, there is nothing mysterious in the action of a suction pump, and lots of other things, for a reasoning mind can easily find the cause.

There are a few fundamental principles, which, if known, the reason for thousands of things, to a reasoning mind, becomes as "transparent as glass," and not only this, but very interesting.

I can find thousands of machinists, who are good workmen, but who know just as much of the laws of motion and force as they do of the inhabitants of the planets, although they have had what is called a common-school education.

As you, Mr. Editor, have suggested, men who have lived long lives amongst machinery, it seems, should have found out something about power; but a workshop is, I think, the poorest place in the world to learn such things.

I think the workshop is the best place in the world to learn many things, but natural philosophy can be taught better in schools.

If natural philosophy was taught as it should be in common schools, I doubt very much if it would be necessary often to criticise perpetual motion inventors.

It is a lack of knowledge of natural philosophy that leads a person to undertake to produce a machine to actually make power out of nothing. If not, why should not a person undertake to produce a machine to make sugar out of nothing? There is too much of a literal meaning put to the word "make."

If you mean by the word "make," to actually create (which is one definition given by the dictionary), then you need to be very careful where you use it.

Machines do well when they alter the forms of material as they were planned to do; to expect a machine to create its own material to operate on is expecting too much. If all people were well acquainted with the laws of natural philosophy, a great many projectors of "wild cat" mechanical schemes would find it advisable to look for some other occupation, and many men would be left with more of their own money for their own uses, than at present.

Perpetual motion machines, when called by that name, are at present at quite a discount; not because people generally know the reason for their failures, but because they know that such things *have been* failures, and that such schemes are risky. This prejudice does not stop at the perpetual motion inventor, but works about as well against the inventor with a really practical and valuable invention. It ought not to be necessary for people to govern their actions by prejudice, and it would not be necessary, in many cases, if the laws of natural philosophy were better known.

Perpetual motion inventors, and perpetual motion frauds, are now finding a satisfactory field to work in, in electricity.

The frauds do not, of course, call their contrivances perpetual motion machines, but manage to find other names that have not been heard before, so they keep clear of a large amount of prejudice, and with the mysterious electric current they pretend to work wonders.

Not long ago a party advertised stock in a company that pretended to own the most wonderful invention ever conceived. In answer to a letter of inquiry intelligence was received that it was a scheme for magnifying power to *any* extent by the use of electricity, and that it was tried and proven to be a complete success.

Perpetual motion inventors have claimed a good deal when they claimed to produce a machine that would create power to run itself, but this new electrical fraud pretends thousands of times more than this. To make the matter more plain the chief fraud pretends that each magnifying machine will multiply the power by 4, and also that the machines are light, cheap and not liable to get out of order. I think the chief projector does not quite understand his scheme, for in the same minute that he tells of being able to magnify power to *any* extent, he tells of moving from a building because he could not get steam power enough.

It seems to be evident that a door-bell battery and a few of these multiplying machines would give him all the power he could possibly want. This wonderful scheme did not originate in the wilds of Africa, but in this glorious country that we sometimes brag off, and it is now being operated in a city noted for the culture and general intelligence of its people.

If natural philosophy was better understood, I believe stock in such a humbug would sell very slowly. You cannot teach such things in workshops. Schools are the places to teach such things, and every person with a common-school education should be familiar with the laws of natural philosophy. Not familiar only with the language used in the text-books, but familiar with the principles which the text books in their *feeble* way undertake to make plain.

I say in a feeble way, for a text book no matter how well it is composed, is a feeble way of teaching natural philosophy.

Schools should be provided with suitable contrivances for experiments in order to make things *actually* understood and interesting.

It is useless to reason with a perpetual motion inventor, for whoever saw one who was not wholly sure that his contrivance was a success? It seems to be a trait of human nature to lie and then swear to it. In a Western town, not long ago, a party claimed to have invented a certain three-ply waterwheel which was claimed to develop 300 per cent. of the power.

On their circular there were testimonials from the most influential men of the town which certified to the correctness of this assertion.

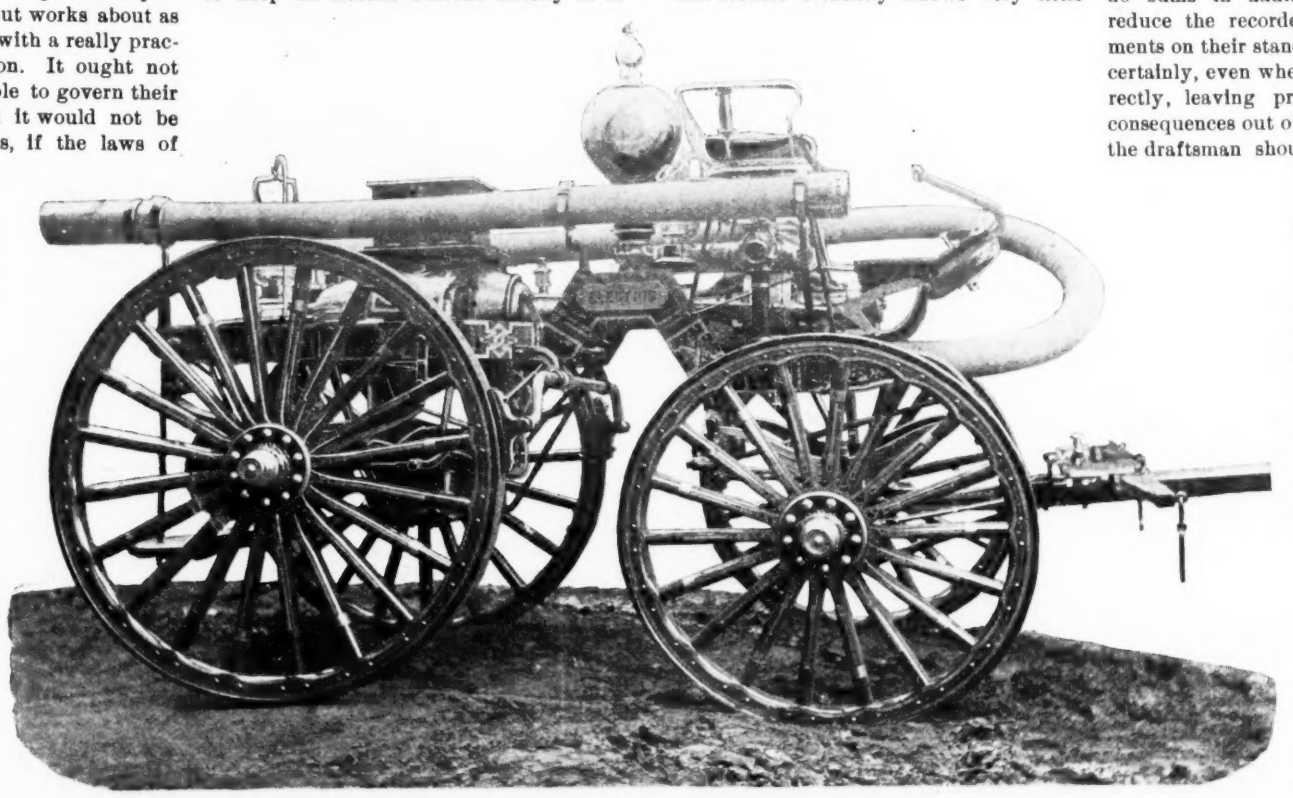
A certain very quick Eastern inventor has got to work in a very quick field, and this is a sample of his lightning-like work:

He has discovered that it is not necessary to keep an electric current strictly in attendance on one motor, but has found that he can switch it into a great many other motors, and then get it back to the first before it is missed.

He says the first motor will run by momentum while the current is engaged somewhere else.

This is about the way things go without a knowledge of philosophy.

A Mechanic.



Electric and Other Fire Engines.

Editor American Machinist:

Two propositions regarding fire engines appeared in your May issues.

The writer of the first article thinks that "all steam fire engines should be self-propelling," and that horses are an unnecessary expense.

Mr. Neuert in his letter goes farther, and proposes to "abandon steam fire engines altogether." He suggests substituting a self-propelling electric fire engine which would be lighter, speedier and easier handled than a steam fire engine.

The first writer entertains a long abandoned theory. Although a goodly number of self-propelling steam fire engines have been built and used, a very few remain self-propellers, and barring one or two exceptions they have been re-built and the self-propelling features discarded. Why? Because they were heavier, slower, and not so easily handled as the prevailing type of steam fire engines.

Mr. Neuert's theory has also been worked out to a considerable degree, and through the kindness of the American Fire Engine Co., I inclose a photograph of an electric fire engine which was built by them four years ago, and is in active service at the Crocker & Wheeler Works, in Ampere, N. J.

Although one may justly be skeptical regarding the achievements to be performed by electricity in the near future, other plans have yet to be devised for generating, conducting and applying electricity before electric fire engines shall supersede steam fire engines.

The ordinary steam fire engine, working as it is required to at a fire, develops from 80 horse power to 100 horse-power, and weighs from 6,000 to 8,000 pounds. Can Mr. Neuert procure an electric fire engine as efficient, as rigid, and as light as such a machine, even without storage batteries? And to add storage batteries of sufficient capacity to make his machine a self-propeller, places his suggestion that such a machine would be lighter and easier handled, out of reach for the present. Regarding speed "en route," complaints are being lodged constantly that our present engines are driven dangerously fast through the streets.

Mr. Neuert evidently knows very little about the fire department in his own city of Chicago, or he would know that an efficient steamer never requires time at a hydrant to raise steam, for the simple reason that the boiler on every fire engine, when in the station, is connected to a heater, and before a steamer can get to the nearest hydrant, have suction and discharge hose connected and laid down, the boiler will have ample steam to start the pumps immediately.

How often has Mr. Neuert timed an engine company's response to an alarm, and how much does he wish to shorten the record? No. 7 Engine Company, of New York, has framed upon the walls of its quarters a certificate of the fact that the horses were hitched and ready to start in one and five eighths seconds from the sound of a bell stroke. The Fire Marshal's report to the city of Chicago for 1893, states that Engine Company No. 1 ran to a fire hydrant, made hose connections, laid 300 feet of hose and obtained 100 pounds water pressure in one minute and eleven seconds. I merely state this to show that the wait at fire hydrants need not be long.

"Quirk," in July 12th issue, not only gives enough food for reflection regarding compressed air engines, but also points out a serious objection to the electric system, viz., that "electric connections are so frequently interrupted when a conflagration is going on," and one small break might cripple the entire fire department, whereas with steam fire engines each machine is an independent plant. Another obstacle which prevents the practicability of an electric fire engine is the cost of an equipment, which would necessarily include a costly system of wires, switches, and connections, a power station with costly plant would require to be erected, a staff of electricians and engineers on duty night and day. Steam constantly on boilers and belts constantly on machines, this would more than compensate for the expense of maintaining a pair of horses in each station. Engineer.

Dimensions on Drawings.

Editor American Machinist:

In a recent issue, one of your correspondents lays it down as a rule for recording sizes on drawings, that all dimensions less than 36 inches (one yard) should be expressed in inches. A like suggestion was made at the recent meeting of mechanical engineers in Montreal. I can understand perfectly the excellence and propriety of this rule for the gentlemen and ladies who make measurements at R. H. Macy & Co. and at Wanamaker's, but the machinists whom I know do not use the yard-stick at all. They do all their measuring with the foot and two-foot rule; and, under the proposed system, they would be compelled to do sums in addition and subtraction to reduce the recorded sizes to the measurements on their standards, with loss of time, certainly, even when they do their sums correctly, leaving probable errors and their consequences out of consideration. I think the draftsman should do the sums and not the machinist, and that all sizes under 24 inches should be recorded in inches, and everything over that in feet and inches, as this agrees with the divisions on the machinists' rule.

Will your correspondent please explain what is to be gained by adopting the yard as the standard of recording sizes for machine work?

Two foot Rule.

Air Compressor.

Editor American Machinist:

In the July 12th American Machinist, under Questions and Answers No. 324 a correspondent asks some questions, and answers are given, to which I venture to take exception, and, as it is a case of very considerable importance to your correspondent whether your answer or mine is correct, I send mine in, that by publication or otherwise you may bring it to his notice. I believe that I am right, but do not assert my infallibility.

The points at difference are:

1st. Diameter steam and exhaust pipes, given 1¾ inches and 3¾ inches, should be 3 inches and 3½ inches or 4 inches.

2d. Size cylinder (steam) required, given 17 inches, should be 14½ inches.

3d. Weight and diameter fly-wheels, given 12 feet diameter, 7,500 pounds each, should be 6 feet, 3,000 pounds each.

4th. Square feet heating surface, given 1,050 = about 80 horse-power, should be 60 horse-power, usual rating.

The question does not figure out quite in the order of these points, but it little matters. I figure it as follows:

The air pressure required will have to be about 15 pounds per square inch, of course, depending upon the number and size of the outlet holes in tank; 10 pounds of this is due to pressure of liquid, which, by the way, would be somewhat diminished by the large amount of air held in suspension. The other 5 pounds will probably cover the friction or resistance requirement.

Assuming 15 pounds air pressure we have about 10.4 pounds M. E. P. in air cylinder, which, by the way, if contents of tank are wanted slightly warm will not require water jacketing.

The diameter of air piston is given 30 inches, hence piston pressure (mean) = 7,280.

In a properly constructed "straight line" air compressor the engine friction never reaches 10 per cent., allowing this figure there the steam piston should receive about 8,000 pounds pressure (mean) which, at 50 pounds M. E. P., is equivalent to a 14½ inch cylinder, which, as usually constructed, should have not less than a 3 inch steam pipe, and this, if long, should be 3½ inches, with exhaust pipe 1 inch larger.

The steam required will be at 200 feet piston speed, 48½ horse power, for which a 60 horse-power boiler should be sufficient.

The fly-wheels in the case of an air compressor differ from those of an engine delivering its power through a belt where uniform belt speed must be maintained. In this case no uniform speed is required, and in one instance it has been conclusively proven to be a very serious disadvantage, causing such excessive strains that parts of the compressors were repeatedly broken which never gave way where ordinary weight of fly-wheels was used. The first effect of lightening noticeable is in the halting at the end of the stroke of the wheels, and the only objection to this, that is while it remains within the limits imposed by this objection, is, in the appearance of an engine making two jumps at each revolution. Any air compressor does this when running very slowly, and when so operated the cut off valves in steam chest must be set to admit steam nearly full stroke to keep engine in motion at all.

I think for ordinary work the compressor should run at 30 R. P. M. without jumping to an unsightly extent, so arranged at 50 R. P. M. no perceptible halt will be seen, and instead of 12 feet by 7,500 pound fly-wheels, I am quite sure your correspondent will find 6 feet by 3,000 pounds to be ample to meet his requirements.

In any case I should advise him to buy a compressor ready-made, or altered as little as possible from regular mining styles, as by so doing he can get something that he knows will work and much cheaper than he can make a doubtful one, and at the same time have a machine that has a market value should he wish to dispose of it. I would suggest that he try to get a regular 14-inch compressor with an unjacketed air cylinder, and I think he will be able to get a 20-inch or 24-inch air cylinder on standard 14 inch bed of some makes. Let him take whatever stroke the maker can give him, 14 inches by 16 inches as now made, or, if he wants longer stroke and can get it at a difference in price which he is willing to meet, he can do so. Stroke makes no difference in capacity so long as piston speed remains constant, in this case 200 feet per minute.

In the above suggestion as to using an unjacketed air cylinder, if no heat is to be allowed in the tank, the air will have to be cooled either in cylinder or between cylinder and tank, but in any case the re-expanding of the air as it comes to the surface of the liquid will absorb as much or more heat than it has imparted.

I again wish to say that I am not infallible, and call upon a comparison of my suggestions with general engineering practice.

Frank Cawley.

[For the diameter of steam pipe we meant to give 2¾ inches and not 1¾ inches.—Ed.]

To Prevent Rusting of Tools, and Bright Parts of Machinery.

Editor American Machinist:

In addition to your Answer, No. 65, 8th February last, let me add as follows: One part of pure crystallized carbolic acid to 12 parts of sperm oil. Mix, and apply with camel-hair brush (as if painting) after the bright parts have been thoroughly cleaned. The above *acid* will also be found a powerful ingredient in mixing with paint in the preservation of iron ships' bottoms.

John Berwick.

Cloncurry, North Queensland.

Mr. Crane Objects.

Editor American Machinist:

In your last issue you tell a correspondent that gas engines are practicable for electric lighting. If you value your peace of mind hereafter, write the man a letter, and tell him under no circumstances put in gas engines for such a purpose. We are now taking out two 40 horse power, and one 100, and replacing them with a steam engine.

Another correspondent you recommend a 17 inch cylinder and a 1¾ inch steam pipe.

Still another one, you speak of creosoting timber. If you have never examined into it, would recommend you to go up to the New York City & Northern Depot, and just a short distance from there is a wood vulcanizing concern. It is quite interesting, and seems to me, valuable. The wood work on the "L" roads are put through the process. W. E. Crane.

[The fact that the company with which Mr. Crane is connected is removing gas engines, can hardly be taken as concluding the subject. Outside this is the fact that gas engines are very successfully used, notably in Europe, for electric lighting purposes, in sizes up to some hundreds of horse power.

The 1¾ inch steam pipe was so manifestly a misprint that it deserves little attention. It has been brought to our notice several times, and the figures have been corrected. We take this occasion to thank Mr. Crane and all others who have brought the matter to our notice.

Regarding the treatment of timber, there is a material difference between using it above ground, as on the elevated roads, and using it under water, as in the instance of the question of our correspondent. For use under water we believe the treatment we gave is the best yet practiced.—Ed. A. M.]

The Fire Engine Question.

Editor American Machinist:

The discussion regarding the substitution of compressed air, or electricity, for steam in operating fire apparatus, has brought out some very interesting statements, some of them true, others "otherwise." A few weeks since, a correspondent stated that "no self-propelling steam fire engine had yet proved a success." This is one of the "otherwise" statements. The city of Hartford, Conn., has in constant use two or three self-propelling steam fire engines, and they "get there" as quick as the other engines that are pulled by horses.

True, self-propellers have been tried and abandoned in several cities at various times, but that is not conclusive evidence that "propellers" are not good fire engines. Many a man has tried and abandoned a "swearing off" of the drinking habit, yet we do not abandon temperance as a failure because of his lack of success.

The propellers of Hartford are at all times connected (when in their engine houses) with a stationary boiler. By this means, steam is always kept up, and in 10 seconds after applying the torch to the mass of combustible in the fire box, the propeller is generating all the steam it needs. Not a second of time is lost. As the gong strikes the alarm, the engineer jumps to his station, touches off the fire, and while this is being done, the driver has climbed to his seat on top of the machine, and has already got the engine under way, using the steam stored up in the boiler from connection with the engine house stationary boiler. And said connection is automatic. It is pulled apart when the engine starts, but being self-closing, it takes care of itself.

So much for the self-propelled steam fire engine in Hartford. It is a success there, and it will succeed anywhere if "pulls," "politics" and "patronage" permit.

In regard to the compressed air fire engine, it requires the same machinery, except the boiler, to operate with compressed air, as with steam. And the boiler is not got rid of either. It must be used for or replaced by a tank for carrying a quantity of compressed air, and as a pressure of 600 to 1,000 pounds will be necessary in the tank, in order to make it contain air enough to drive the engine for a certain length of time, there is no reduction of weight possible in that direction, for the tank would have to be built larger and stronger than the boiler now used. The fire, too, may not be got rid of. Use that cylinder full of highly compressed air, and it will freeze up cylinder, valve, and perhaps engineer, too, if the air be not heated before being used.

As "Quirk" stated in the American Machinist of July 12th, compressed air will escape through a very small hole. Like electricity, "you think you have it, and it's gone; then, the first thing you know, it's got you."

If the compressed air system should be adopted, it would be a very foolish piece of work. A system of piping would have to be laid, capable of sustaining 100 to 200 pounds pressure per square inch. The existing water system of piping is good for 100 pounds. The maximum pressure indicated upon any working steam fire engine water-pressure gauge is 120 pounds. Ordinarily from 80 to 100 pounds.

Here then, is an opportunity to get rid of the proposed foolish engineering. Put in the proposed new system of piping, with a strength to stand 300 to 400 pounds pressure. Then pump the fire water supply directly through this new system of piping, and do away with the hydrants now attached to city service pipes, with compressed air, and with the fire engines themselves.

Throw them all away, and force water through the fire service pipes under high pressure so that the highest buildings may be covered with direct hydrant streams. Do away with engines, engine companies, high-priced, short lived fire engine boilers, and high-priced coal that is burned under them. Organize all the firemen into hose companies. Divide up the fire districts into smaller ones. Thus permitting the ground to be more thickly covered with protective apparatus. By so doing, one of the light hose rigs will be at a fire much quicker after an alarm is given, and the stream which plays on the newly discovered fire puts it out easily, with but little loss by fire or damage from water.

"Oh, it won't pay to do that," will probably be the cry. "We've got the old hydrant system, and we have got to keep it." "We don't care anything about the horses; just as lieve hitch on a trolley pole as not, but we don't intend to throw away fire engines—not for any high-pressure hydrant business any way."

Such will probably be the wail of city officials when the matter is broached to them. They are bound to follow in somebody's footsteps, so they get to walking in those of their father, and can't seem to get out of the fashion. But the steam fire engine is doomed. It may not give way to the electric motor, or to compressed air, but it surely will be dispensed with in the immediate future, in large cities especially.

A few years since the writer advocated the use of the electric motor for fire engine operation, power to be taken from overhead lighting circuits. Plugs, terminals and switches to be attached to poles beside every fire hydrant. Such a system would make it possible to dispense with the heavy fire engine now in use. The boiler would be thrown away, but the pump and air chamber must be retained, and the engine must be replaced with a motor of equal or greater weight, leaving not as large a margin of saving in weight as might be expected, but time, and cost would be saved.

A ten horse-power motor could not be connected up without adding a weight of somewhere near 300 pounds to the weight of pumps and other fixtures. For self-propelling fire engines, electricity evidently is "not in it." Storage cells would make a load many times as great as the boiler now in use, and the lighting circuits could not be used, because there is no way of applying the trolley to them. Wherever there are trolley lines, the "electric propeller" fire engine would get there on time, but trolley wires don't go everywhere, they follow the principal streets, and the fire engine which depended upon them, would be a high toned affair which could not get at a fire in the back alley or on a side street.

Another thing, the "trolley fire engine" would find itself very badly "left" in a very few years hence. And this is the reason: the electric wires (trolley and lighting) having proved that they will not die by "hanging," are to be all "buried alive," within less than five years, so it is of no use to rig up our fire engines with trolley poles.

To sum up. Steam for fire engines is costly. So is condensed air. Electricity does not fit, but can be used for operating at fires but not for propulsion of engines. Why, then, is it not better to "improve" the fire engine by throwing it away, and do all the pumping at one or two central stations, with high-duty compound condensing steam pumps or engines, and thus reduce the cost all around with the exception of the piping?

James F. Hobart.

"Fraudulent Testing."

Editor American Machinist:

The statement in the editorial of your issue of July 19th, that the resistance of the heavy parts of a testing machine to being put in motion is registered in addition to the stress put upon the testing machine, it seems to me is not strictly accurate. After the parts have been put in motion, at the beginning of the test, neglecting friction, it requires no force to keep them in motion at the same speed. Suppose, however, there is an acceleration of, say, 1 inch per second, an exceedingly high rate of speed for a testing machine, and that the moving parts weigh 1,000 pounds. How much force is required to produce the acceleration?

The force equals the product of the mass and the acceleration, or $m\,(v_1 - v_0) = \frac{w}{g}\,(v_1 - v_0) = \frac{1\,000}{32.2} \times \frac{1}{12}$ foot $= 2.6$ pounds. This amount is the resistance of the parts, weighing 1,000 pounds, to being put in motion, and during one second acquiring a velocity of $\frac{1}{12}$ foot per second. But even this force, small as it is, is not registered by the testing machine, for the weighing part of the machine is attached to the stationary end of the test piece, and receives no motion, except that of the very short oscillations of the short end of the main lever, or of the weighing platform, and no stress except that actually transmitted through the test piece. The parts that move with the elongation are at the pulling end of the machine, and the force which gives them acceleration does not pass through the piece, nor is it registered.

Wm. Kent.

Fire Engines.

Editor American Machinist:

Allow me to suggest another arrangement for improving the fire engine in addition to what others have said.

It seems to me that the ordinary fire department horse has demonstrated his ability to transport a moderate load to a fire in a sufficiently short time. He can develop several horse-power for a few minutes, and can generally be relied upon.

But it seems to me that the fire engine is certainly the elephant on our hands. Where the pressure in the city mains is not sufficient for fire purposes we fire up a steam boiler and get a steam pump to working before anything can be done. For this part of the work the compressed air motor might be made to do good service, but why not a compressed water motor instead?

We have water on tap at every hydrant, and at a pressure sufficient to operate a small turbine or other motor to drive a pump.

Suppose we have water at a pressure of 60 pounds at the hydrant, and can operate our pump and turbine with an efficiency of 50 per cent. for the two combined, we

can use one-half the water at the hydrant to operate our machinery, and deliver the other half to the hose at a pressure of 90 pounds.

This machinery can certainly be constructed as light as the ordinary fire-pump, and by leaving off the boiler we may substitute a hose reel in its stead, and be prepared for business the moment we reach the hydrant. JOHN D. RIGGS.

Automatic Band Re-saw Sharpening Machine.

We illustrate herewith a machine designed especially for sharpening the teeth of band re saws by grinding; emery wheels being used. As will be seen, the machine is simple in construction and easily operated. The saw rests upon rollers which are adjustable to any required length of saw, and the machine operates upon saws from 2 inches to 6 inches wide and having teeth from ½-inch to 3 inches apart, of any ordinary shape, leaving the teeth much more uniformly and better sharpened than is practicable to do by filing. About forty-five teeth per minute is the usual working speed of the machine. It is built by S. C. Rogers & Co., Buffalo, N. Y.

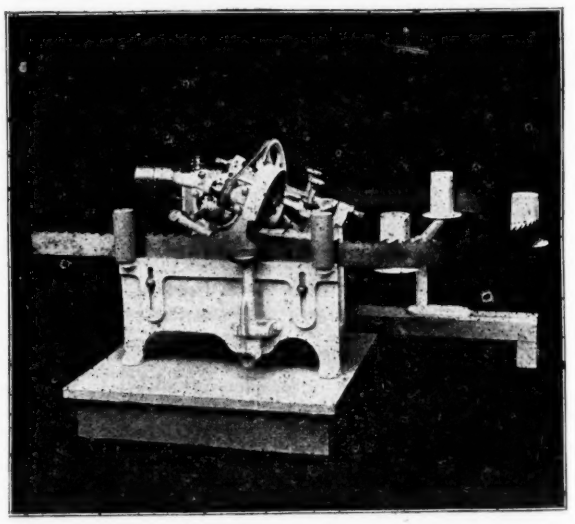
Human Nature in the Machine Shop.

BY FRANK RICHARDS.

We have had of late in the AMERICAN MACHINIST some remarks upon human nature in the machine shop, and urging its recognition as an important factor to be dealt with in shop management. There is no new discovery about this. We might go farther than those who have touched the topic have yet gone, and say that human nature is the most important of all the elements to be considered and directed by the proprietor, the superintendent or the foreman. The labor account ranges far higher than the material account in many mechanical businesses, and the material cost itself is made up of a large labor cost and some "raw" material cost in a previous stage of production, and so on, backward, until at last we find that human labor and human nature are almost the only things to be reckoned with in computing the cost of production, so that the importance of so handling human nature that the best results may be secured is in no danger of being exaggerated. It would seem that in our institutions of learning, and especially in the technical schools which in these days are assumed to train and equip the guides and supervisors of mechanical production, a professor of human nature and common sense should be one of the most necessary and important of functionaries, and the technical journal that sets out to cater to the whole round of mechanical interests should last of all ignore the human nature that is the ubiquitous and predominant factor either of success or of failure.

The habit hitherto has been to regard the metals and the other materials of manufacture as the certain and reliable elements to be dealt with, while human nature has been regarded as the uncertain and capricious element. In this view of it human nature would seem to require the most study, but such study has been avoided as unpromising if not actually unprofitable by reason of this savor of uncertainty. But as we grow wiser and go deeper into things we find that all the material which we handle is more or less uncertain. The steel and the cast-iron need constant testing and watchfulness to secure any reliability of product. On the other hand, the assumed uncertainties of human nature are largely dissipated as we learn its proper manipulation. The cause is not more unerringly followed by its appropriate effects when a bar of iron is acted upon than when a man is acted upon. We may not be able to predict the results with equal accuracy in either case because we cannot trace with sufficient minuteness the ramifications of either operation.

As we study human nature from a mechanical point of view, one of its most striking characteristics is its responsiveness. Not only do the effects inevitably follow the producing cause, but they correspond in character to that cause. Nowhere on earth does like produce like more certainly than when mind acts upon mind. The full recognition and constant remembrance of this simplifies the task of management. But such a simple truth as this is too often ignored entirely. One of the greatest of mistakes, probably, is in the idea of driving a machine shop. The machinery of the shop is driven by a flexible and yielding belt and it goes all right. Some would drive the men with a battering ram and think they should go all right. You can lead an animal, human or not human, and talk to him encouragingly and get him to draw an honest load, but if you undertake to push him, or if you overload him, he balks. Imposition rouses opposition. The biggest humbug in machine-shop management is the hustler. Your true mechanic judges of the excellence of a system of machinery by the smoothness and noiselessness of its movements, and the true engineer keeps everything well oiled. Oil not only makes everything run smoothly but it saves power and increases the product. Your hustler is the fellow that comes along and throws sand into the works, and occasionally a cobblestone, and the more things rattle and grate the more the remark goes around, "Oh, he's a hustler from Hustlerville." There are actually proprietors who estimate a foreman or a superintendent according to the friction that he creates, when, in fact, friction is the thing of all others to be avoided. This need not be misunderstood. A man may be a man and may be a most successful manager without being a hustler, but he must be a man. Men will not respect a man that they can impose upon, and they will not impose upon one whom they entirely respect. Just treatment, and nothing but just treatment, will beget faithful service. Complete justice is not satisfied entirely by the pay roll. Whether through ignorance or otherwise never to show appreciation of faithful or excellent work is not just treatment. To unceasingly nag the worker and the drone alike, and to be forever and universally dissatisfied, or to seem to be so, is not just treatment. A large liberality in one spot will not cover a small injustice in another spot. No man can count his workmen his friends who is not a true friend to them, and he cannot reach a large success without such friendship. It is not to be expected that justice will be found where skill and knowledge are wanting. If they go together men will always voluntarily respect them, but the charlatan and the fakir is sooner or later seen through and detested.



AUTOMATIC BAND RE-SAW SHARPENING MACHINE.

Much might be said of the necessity, as a condition of successful management, of securing and maintaining a general right feeling among the men, a right feeling toward each other, toward the management and toward the entire business. Between a thorough and hearty co-operation, upon the one hand, and mutual antagonism of interest and purpose, upon the other, may easily lie the difference between success and failure for the business involved. This difference of tone in the shop, this sentimental difference, if anyone wants it stated in that way, may not reveal itself wholly at any one time in the immediate and actual output. The helpful and suggestive and neighborly feeling among workmen promotes better methods of doing things, prevents waste of time or material, and foresees and averts delaying or disabling accidents to the machinery, while, on the other hand, there is no limit to the mischief that quarrelsome men, or men with malignant spite against the management, or against things in general, may do. We know how sometimes for a day things will go all wrong in the best of shops, and how different it then is from the days when things go all right. But when the all right and the all-wrong are the habitual conditions of two different shops it will be hopeless for the one to try to compete successfully with the other in business.

At one of the schools that lately held its annual graduating exercises a prize was awarded to one of the scholars for "general good influence." It would be hardly possible to establish such a prize in the shop or to make any formal recognition of such a valuable service as a man may render, and often does render, but the foreman or superintendent should appreciate and prize it.

With men as they are, and not with ideal men, it is quite possible to so conduct a business that there shall be fair dealing all around, good feeling all around, and so that all shall work together toward the success of the whole and achieve and maintain it. Human nature must be recognized as an ever-present and active force, and as a guide toward the best understanding of it, probably nothing better may be said than the "He judges men most truly who judges them most kindly." Treatment that parallels such a judgment should reach the heights of success.

The "Alabama."

At the time of the building of the "Alabama" it was the object of the Lairds to get her away before she could be stopped by the British Government, and this was accomplished by a ruse which had some very inconvenient consequences to a good many people. There was a trial trip arranged, and a large number of invitations were issued, and when the "Alabama" sailed down the Mersey for a few hours run she had on board a large number of ladies and gentlemen. So warm had the position become, and so certain were Lairds that there would be an embargo laid on the ship, that she never returned from that trial trip. The pleasure party was prolonged for several days and then the unwilling passengers were landed at Madeira to find their way home somehow. It was always said in Lancashire that old Laird ought to have been compelled to make good the whole of the Geneva award, for he was fully aware of what he did when he built the ship, and the trick by which he got her away ostensibly on a trial trip with a picnic party aboard was itself enough to have condemned him in costs. W. H. B.

Four men were recently dangerously, some of them fatally, injured by the blowing out of a converter bottom at the Carnegie Homestead Works.

Missed the Trip.

Just before the "Minneapolis" sailed from here last week for the trial trip which has proved so successful, Dr. B. Estanislaus Zeballos, the Argentine Republic's Minister to this country, who had been invited to go along as a guest, walked up the gangplank in Cramps' shipyard with a servant. He was shown to the room which had been reserved for him, and which, in view of the crude condition of the cruiser consequent upon her trial trip, he found plainly furnished. He also discovered that the president of the trial board and Chairman Cummings, of the House Committee on Naval Affairs, had staterooms that were somewhat more roomy and better situated, but no better furnished.

Dr. Zeballos at once declared that in his capacity as Minister to the United States from the Argentine Republic he could not accept any accommodations on the ship which were not equal to those assigned to any other person, and he made a request for a better room. It was impossible for Captain Sargent to find such accommodation or to turn Mr. Cummings or any other official out of the quarters to which he had been assigned. Dr. Zeballos declared that, under these circumstances, he could not accompany the ship on the trip and would leave forthwith. The officials of the Cramp Company expressed their regret very politely, and Dr. Zeballos, with servant trailing along behind him, walked down the gangplank and thus preserved the dignity of the Argentine Republic, but missed the most beautiful trial trip that has ever been made.—*Philadelphia Record.*

William Cox, civil engineer, P. O. Box 541, Stapleton, N. Y., has brought out an instrument for computing the flow of gas through pipes. It is a simple instrument, easily manipulated, and with it reliable results are obtained with practically no labor. It has been adopted in many gas works.

"Strangers in India," said Prof. E. P. Worthington, of Boston, at the Southern last night, "are usually a good deal surprised at the curious ability possessed by the Hindoos to use their feet and toes in various industrial occupations. In the native quarters of the town it is no uncommon sight to see a butcher seize a piece of meat in his hands and cut it in two with a stroke of his knife held between the first and second toes of his foot. The shoemaker uses no last, but turns the unfinished shoe with his feet, while his hands are busy in shaping it. The carpenter also holds the board he is cutting with his great toe, and the wood-turner uses his tools as well with his toes as his hands. This use of the feet to assist the hands in their labor is not the mere result of practice, but, as investigators have proved, is principally due to the fact that the Hindoo foot is quite different from ours in its anatomical conformation. The ankle of the Hindoo and the articulation of the back of the foot permit considerable lateral motion. Then the toes possess a surprising mobility and can be moved freely in all directions. The articulation of the hip is also peculiar, and this renders it easier to use the toes in handling objects by enabling the Hindoo to sit in a squatting posture much more comfortably than we can do."—*St. Louis Globe-Democrat.*

An Advance of Wages.

The Kearney & Foot Co. re opened their works recently, after a shutdown of nearly a month for their annual inventory and repairs. This concern is now employing about four hundred hands. A pleasant feature of the re-opening was a surprise to the men in the shape of a notice reading as follows:

As the business conditions of the country will not warrant our running full time, with a view to making the burden as easy as possible to our men, we shall restore wages as existing before the 10 per cent. cut made some months ago. This advance to take place on next pay day.

During their twenty years' business experience this company has found it necessary to reduce wages, owing to business depression, but twice, and in each instance have voluntarily restored the wages without consulting their employes.—*Paterson (N. J.) Call.*

AMERICAN MACHINIST

Communications relating to the reading columns should be addressed to the Editor. All other communications should be addressed:

AMERICAN MACHINIST,
203 BROADWAY, NEW YORK.

PUBLISHED WEEKLY AT
203 Broadway, New York.

HORACE B. MILLER, Pres't and Bus. Manager.
LYCURGUS B. MOORE, Treas. and Sec'y.

F. F. HEMENWAY, Editor and Mech. Engineer.
J. G. A. MEYER, } Associates.
FRED J. MILLER, }

Special Announcements.

☞ *Positively we will neither publish anything in our reading columns for pay or in consideration of advertising patronage. Those who wish to recommend their wares to our readers can do so as fully as they choose in our advertising columns, but our editorial opinions are not for sale.*

☞ *Every correspondent, in order to insure attention, should give his full name and address, not for publication, but as a guarantee of good faith.*

☞ *We are not engaged in procuring patent rights, or in selling machinery, nor have we any pet scheme to advance, or hobby to ride.*

☞ *We invite correspondence from practical machinists, engineers, inventors, draftsmen, and all those specially interested in the occupations we represent, on subjects pertaining to machinery.*

☞ *Subscribers can have the mailing address of their paper changed as often as they desire. Send both old and new addresses. Those who fail to receive their papers promptly will please notify us at once. Date on wrapper denotes week with which subscription expires.*

Subscription.

$3.00 a year in advance, postage prepaid, in the United States, Canada, and Mexico.
$4.00 a year to Other Countries, postage prepaid

Advertising.

Transient, 35c. per line, each insertion.
"Business Specials," 50c. a line.
No Commission allowed to Advertising Agents.

The American News Company,
Publishers' Agents, New York.
DEALERS SUPPLIED BY
The Albany News Company, Albany, N. Y.
The American News Company, New York, N. Y.
The Baltimore News Company, Baltimore, Md.
The Brooklyn News Company, Brooklyn, N. Y.
The Buffalo News Co., Buffalo, N. Y.
The Central News Company, Philadelphia, Pa.
The Cincinnati News Company, Cincinnati, Ohio.
The Cleveland News Company, Cleveland, Ohio.
The Colorado News Company, Denver, Colorado.
The Detroit News Company, Detroit, Mich.
The International News Company, New York, N. Y.
The Minnesota News Company, St. Paul, Minn.
The Montreal News Company, Montreal, Canada.
The National News Company, New York, N. Y.
The Newark News Company, Newark, N. J.
The New England News Company, Boston, Mass.
The New Orleans News Company, New Orleans, La.
The New York News Company, New York, N. Y.
The Northern News Company, Troy, New York.
The Omaha News Company, Omaha, Neb.
The Pittsburgh News Company, Pittsburgh, Pa.
The Rhode Island News Company, Providence, R. I.
The San Francisco News Co., San Francisco, Cal.
The South West News Company, Kansas City, Mo.
The St. Louis News Company, St. Louis, Mo.
The Toronto News Co., Toronto, Ontario, Canada.
The Union News Company, New York, N. Y.
The Washington News Company, Washington, D. C.
The Western News Company, Chicago, Ill.
The Williamsburgh News Co., Brooklyn, E. D., N. Y.
The Wisconsin News Company, Milwaukee, Wis.

The International News Company,
BREAM'S BLDG'S, Chancery Lane, LONDON, E. C., ENG., or Stefanstrasse 18, LEIPZIG, GERMANY, will receive subscriptions for the AMERICAN MACHINIST, at 16/6 per annum, English currency, or 17 marks per annum, German currency, postpaid.

Subscriptions received in Paris, France, by E. TERQUEM, 31 Boulevard Hausmann, at 21 francs per annum, postpaid.

Subscriptions received in Australia by W. WILLIAMS, 17 and 21 Fink's Buildings, Melbourne.

NEW YORK, AUGUST 2, 1894.

CONTENTS.

	PAGE.
Improved Hendey-Norton Lathe	1
Machine Shop Milling Practice. By Horace L. Arnold	1, 2
Economical Steam Compression. By M. E.	3, 4
Letters from Practical Men: Draftsmen and Their Work. By C. S. Beach... Removing a Piston Head. By Almon Emrie... A Neglected Study. By A Mechanic... Electric and Other Fire Engines. By Engineer... Dimensions on Drawings. By Two-foot Rule ...Air Compressor. By Frank Cawley... To Prevent Rusting of Tools and Bright Parts of Machinery. By John Berwick . Mr. Crane Objects. By W. E. Crane... The Fire Engine Question. By James F. Hobart ..."Fraudulent Testing." By Wm. Kent . Fire Engines. By John D. Riggs	4, 5, 6, 7
Automatic Band Re-saw Sharpening Machine	7
Human Nature in the Machine Shop. By Frank Richards	7
The "Alabama"	7
Missed the Trip	7
An Advance of Wages	7
Some Great Discoveries in Air Navigation	8
Compound Locomotives	8
Death of Prof. O. G. Heilman	8
Questions and Answers	8, 9
The Manufacture of Very Accurate Straight-Edges. By F. L. O. Wadsworth	9, 10, 11, 12, 13
Manufactures	13, 14
Machinists' Supplies and Iron	14

Some Great Discoveries in Air Navigation.

A daily paper published in a town near New York contains an account of the visit to that town of an inventor of a flying machine which is to navigate the air at the rate of 300 miles an hour. This inventor, who was born in Germany, but has drawn his inventional inspiration from the air of Brooklyn, proposes to take advantage of a newly discovered property of air that he calls "anthexis," which, when translated, means what the bicycle rider and the parachute man recognize as air resistance.

By request of the aforesaid local paper (which had previously scooped its rivals by "exclusively announcing" the arrival of the great inventor) he wrote out for its columns a statement of the principles involved in his invention, from which we quote some of the brightest passages. For instance, he says:

Animal locomotion is the prototype of artificial locomotion. The railway locomotive conforms to animal locomotion in the matter of fulcrumage; and coincident with this conformity is the locomotive's capacity for speed, obtained at an abnormal expenditure of power. But the steamship diverges from animal locomotion, both in sustenance of ship and in fulcrumage; and coincident with this divergence is the steamship's deficiency in speed and safety, and in requiring an abnormal amount of power for the limited speed it does make, doubly limited, as compared with the speed of the locomotive, and because the resistance of water is so much less than that of land.

Animal locomotion is governed by one and the same law; but for the air that law has a different method of application from that obtaining on land, namely as to sustentation and fulcrumage.

He then goes on to explain that if the foregoing were understood no further attempts would be made to fly by other means, such as balloons, aeroplanes, etc., which is probably strictly true. The inventor further states that:

Animal locomotion comprises four requirements, namely: (a) a proportion of weight to volume of body in the locomotor, such as to make this heavy and firmly adhesive to its locomotive element; (b) support of the locomotor by its locomotive element; (c) locomotion of the locomotor through its own force; (d) fulcrumage, to enable the locomotor to apply its force against itself.

Though the inventor does not so state, it is readily apparent that if this were generally understood there would be no further attempts to locomote by any means whatever.

It is stated that if the inventor receives sufficient encouragement, he will locate his works in the town and that the mayor, an ex mayor, an ex judge and an ex postmaster, with other leading citizens, are greatly interested. Which, if true, would seem to indicate that a new mayor and a new set of ex-officials of various kinds would be something of an improvement in that town.

Compound Locomotives.

Surprise is frequently expressed that after so much of trial the standing of the compound locomotive with the motive power of the railroads of the country is apparently about as far from being established as ever. Amongst those who control the motive power there are those who have used compounds and express themselves as finding material saving of fuel in their use, and there are those who find no saving; those who find they are costly in the way of repairs, and those who find to the contrary. Some believe the compound locomotive is the coming machine, but that the proper construction has not yet been developed, others believe nothing of the kind, and so on through the chapter of advisability and probability.

But it should be remembered by those who believe progress is slow that the general introduction of the compound engine for stationary and marine purposes met with much opposition, and was the work of years. If it is reasoned that the settling of the question of compounding for these purposes should simplify the matter in the case of locomotives, the answer is ready and entirely pertinent, that the conditions of operating are quite different; and, besides, the locomotive is a non-condensing engine, and the non-condensing compound engine has not yet fully worked its way into stationary practice.

The diversity of opinion in regard to compound locomotives, puzzling as it may seem, is natural enough. There are compound locomotives and compound locomotives, and compound engines for stationary purposes have been made in abundance that were inferior to good, simple engines. And besides this there are prejudices to be overcome, and other obstacles in the way.

There is yet much—nearly all—to be learned about compounding in railroad practice. It looks as if the right place for the compound locomotive is yet to be found; that is, that there are conditions of service where it is superior to the simple engine, and places where the reverse is true. Still it may be so developed as to be best for all purposes. The matter is not likely to be definitely settled for some years.

One of the most recent publications in relation to the comparative economy of the two systems is on the authority of William Buchanan, in which the comparison is between the New York Central simple engines 888 and 999, and the London & Northwestern compound Greater Britain. Different conditions, however, known and unknown, unfortunately render the comparison valueless in any scientific sense. It is, however, well enough to note that the coal consumption per unit of work of the simple engines was less than that of the compound. But, as before stated, the comparison, for obvious reasons, was of little value.

Experimenting will, no doubt, keep going on, both by builders and users of compound locomotives, until they will, eventually, find their level, whatever that may be.

There is now in session at Albany a constitutional convention—a body that proposes to map out ground for the re arrangement of the fundamental principles of the laws of the State, and one of its members—a Mr. Tucker, of New York City—has tackled the provisions of the statute law that fixes the value of a man's life in the State of New York at a sum not exceeding $5,000. The utter absurdity of such a limit has been shown time and again, and now it looks as if this might be changed. The change, as proposed by Mr. Tucker, is embodied in the following:

No statutory limitation shall be placed upon amount of damages recoverable by civil action for loss of human life.

This will, if it passes into law, make railroad and other corporations more careful of human life than they are at present, forcing them to use appliances to the end of greater safety. There might be some little difficulty in fixing, on trial, the value of a life, but, on the whole, juries could be depended upon to look after the matter. It would seldom, we think, be fixed at so low a sum as $5,000. The real value of such a law would be in the fact that it would result in fewer men being killed, which is the important thing.

We know only in the most general way of Mr. Gustav N. Schwab, who appears to be put forward by the Chamber of Commerce of New York to present the views of that body in relation to the bridge across the North River. Mr. Schwab is not an engineer, so far as we know, but he has ideas in relation to the bridge that would do credit to any engineer. We have, before this, referred to his views in regard to blocking up the river, and it is a satisfaction to know that he stands by these views as first expressed. There is, in all such things, a sort of feeling of expediency—a getting over the matter just for the present and letting the future take care of itself—that needs a balance wheel in the way of regulation. Not a single foot of the river should be blocked by the proposed bridge. New York is not yet through growing.

It seems that under recent and prevailing conditions anthracite coal has accumulated in the hands of its producers. It had been agreed that the production for July should be 3,500,000 tons, but this turned out to be "excessive," which means that that quantity was not taken at the price fixed by agreement of the sales agents. Those companies which found their stocks accumulating, not being able to stimulate trade by making concessions in prices, wanted the output reduced, while those companies that supplied the Western markets and were not overstocked wanted the production maintained. Under ordinary commercial rules the Eastern surplus would have gone West, but not so with a product so closely controlled and monopolized as is coal.

There has been some attempt to make out that trials have shown that the Carnegie armor plates, on account of whose defects a fine was assessed, were in reality all right, and that the firm are entitled to receive back the money paid as a fine. Captain Sampson, who conducted the investigation into the matter, seems, however, to have pretty effectually disposed of the story, and states unequivocally that not only has the Carnegie firm no cause to complain of their treatment, but that they know it, and are not at all likely to make any complaint whatever. He says, in concluding the subject:

"The Carnegie Company has no complaints to make to us, whatever its champions may write for the consumption of the general public. No demand for the repayment of the penalty has been made upon the department, and I am safe in saying that none will be made."

Getting high muzzle velocity without destructive chamber pressure is the problem in the construction of large guns. The skill of the mechanician has been taxed to about the utmost to provide strength for the gun. Now the skill of the chemist is taxed to devise a powder that shall burn just right to accomplish the end aimed at. The starting of the enormously heavy modern projectile without danger to the gun, and the gradual increase of velocity up to the muzzle, all the time avoiding danger, is the problem, the solution of which is being ardently sought at the present time. Glory, and money, too, lies in the direction of the successful effort to the more easily and successfully destroy human life.

Death of Prof. O. G. Heilman.

Prof. O. G. Heilman, of Sibley College, Cornell University, died July 15th, in Williamsport, Pa., of lockjaw, brought on by a wound from the premature explosion of a cannon July 4th. He was an instructor in the department in experimental engineering, and had special charge of the large triple-expansion engines. He graduated from Sibley College in 1891 with high honors and had been employed as instructor since his graduation. He was a junior member of the American Society of Mechanical Engineers.

Questions and Answers.

Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.

(356) C. M. C., Pensacola, Fla., writes: Please inform me of the best method of dissolving rubber, chemicals preferred. *A.*—The solution of India rubber, like its fusion, is a vexed point. There is little question that it can be dissolved by proper treatment. Usually naphtha, carbon disulphide or benzole are used as solvents, the choice being guided by motives of cheapness and efficiency.

(357) J. F. A., St. Kitts, West Indies, writes: Please give name of practical work treating on molding and casting. *A.*

—"The Iron Founder," "The Iron Founder Supplement," "Encyclopedia of Founding," all by S. Bolland; "American Foundry Practice," "Molders' Text-book," both by T. D. West, are good books. All these books are published by John Wiley & Sons, 53 East Tenth street, New York.

(358) W. M. M., Elgin, Ill., writes: Some time ago there appeared in the AMERICAN MACHINIST a scheme for preventing flies from eating the ink off a drawing. Kindly send me the copies of your issues containing the items. *A.*—We cannot send you copies of these issues as they were published in 1892, and we keep no stock prior to 1893. To stop flies from eating the ink off drawings, mix a little acetic acid or vinegar with the ink. Flies will not touch the prepared Higgins American India ink of either the general or water proof kind.

(359) F. E. W., Lawrence, Kan., asks: Would you consider it practical to have a lot of half-worn files sharpened by sand blast, or should they be recut? If they can be sharpened by sand blast, please inform me by whom it can be done. *A.*—Sand blast is sometimes used for sharpening files, but this is generally done in establishments where the files are used. We prefer to have the files recut. 2. Is there any other practical use for old files? *A.*—They may be used for scrapers, but generally their use is very limited; a stock of old files has very little value.

(360) H. C., Paulding, O., writes: Kindly give the reason why in gas engines a charge of gas is not exploded in each end of the cylinder, that is, on each side of the piston. *A.*—The early gas engines were constructed on this principle, and, in fact, there are some in use now in which the gas is exploded at each end of the cylinder. But it has been found that the efficiency of the engine is increased by reducing the number of explosions during a revolution. It may be said that, while the steam engine has been improved by passing from single acting to double-acting during each revolution, the gas engine has been improved by passing from double-acting to single-acting during each stroke, and finally to one action during two revolutions.

(361) R. K., Boston, Mass., writes: Kindly inform me where I can find the correct dimensions of socket and spigot pipe joints. The formulas I found do not agree with the measurements taken from pipes now on the market. I have to make a set of patterns of these pipes. *A.*—You will find a small drawing to scale and description of this joint in J. C. Trautwine's "Engineer's Pocket book." This, with the dimensions of pipes at present in use, should enable you to make the patterns. 2. Kindly inform me where I can get a practical book treating on the strength of materials. *A.*—"Text book on the Mechanics of Materials," by Prof. M. Merriman, and "Elementary Applied Mechanics," by Prof. T. Alexander, are good books. These you can obtain from any dealer in scientific works. 3. Are there any books treating on valves and fittings for water, gas and steam? *A.*—We do not know of any.

(362) H. G., Owensboro, Ky., writes: We want to place a fire-alarm on the water-works, and want it radically different from the every day whistle. We do not like the "wild cat" or piston whistle. How would a siren do under 100 pounds pressure, and a 2 inch pipe, and where can we obtain one? *A.*—A siren will answer your purpose very well. Dealers in machinists' supplies may be able to furnish you with one, but we are inclined to believe that they are not kept in stock. It will probably have to be made to order; in that case we do not see why you cannot make it in your own shop. 2. We have just made an 8x24 inch bell whistle, the slot ring is $\frac{3}{64}$ inch wide; can we improve the sound by increasing or decreasing the width of slot? *A.*—We should not increase it, but decrease it to $\frac{1}{32}$ inch. 3. Should the slot ring be equal to the inside or outside diameter of the bell? *A.*—We should make it $\frac{1}{8}$ inch less than the outside diameter of the bell.

(363) K. S., Mt. Carmel, Ill., writes: I have an anvil which weighs about 200 pounds; its face has been hammered till it has become sunken and its edges broken off. I want to know if the temper can be drawn, the face planed, and then tempered without incurring much expense. The tempering, in my opinion, is the most difficult part. How should I go about it? *A.*—To draw the temper, heat the anvil to a cherry red, and then let it cool slowly; then plane off or dress the face as desired. To temper the face, heat it to a cherry red, and then place the anvil with its face up in a tank filled with water; the depth of tank should be such that the water in it will just cover the face of the anvil, then play water upon it by means of a hose, until the face is cool. If there is a waterfall near you, the face of the anvil can be tempered by simply placing the anvil, after its face has been heated, underneath the fall. The expense of dressing and tempering the face as above described should not be very great.

(364) F. C., Penn Yan, N. Y., writes: Given a vertical falling column of water, and a pipe suspended perpendicularly therein, its lower end open, and terminating at a point where the surrounding water has attained a velocity of 15 feet per second. The upper end of the pipe is connected to an air chamber; would the suction produced practically exhaust the chamber to the vacuum point? *A.*—As an air exhauster this arrangement will be a failure. 2. How many square feet of surface should a common keel condenser have to give good results with a triple-expansion engine whose pistons are $1\frac{1}{4}$, $2\frac{1}{2}$ and $3\frac{1}{2}$ inches diameter, stroke $2\frac{1}{2}$ inches; steam pressure 160 pounds, cutting off at half stroke; speed 600 revolutions per minute? *A.*—About $2\frac{1}{2}$ square feet. 3. What should be the capacity of air pump? Will it be practical to run the air pump from the shaft which makes 600 revolutions per minute? *A.*—We are not in favor of running a small air pump at a speed of 1,200 strokes per minute, which it will have when connected direct to the shaft. We should advise the use of an independent single acting air pump, with water and steam cylinders 2 inches diameter and $2\frac{1}{2}$ inches stroke, and then run this pump at a speed which will meet the requirements of the engine.

(365) Q. A. S., Boston, Mass., writes: In answer to Question 314 you give for 6x6-inch engine running at the rate of 400 revolutions per minute, a boiler with 70 square feet of grate surface, and 2 240 square feet of heating surface. Is not this much too large? Or, will you inform me by what rule it was calculated? *A.*—You have read the answer hastily. In the first place, it is not a 6x6-inch engine; it is a compound engine, with cylinders 6 and 18 inches diameter, and 6 inches stroke, the horse power of this engine is estimated at 175. Then again, the question calls for a boiler large enough for two of these engines, or a boiler large enough for 350 horse power, allowing 3 pounds of coal per horse power per hour; then, $350 \times 3 = 1{,}050$ pounds of coal will be burnt per hour, and allowing 15 pounds of coal per hour per square foot of grate surface, we have $\frac{1\,050}{15} = 70$ square feet for the grate surface, and allowing 32 square feet of heating surface per square foot of grate surface, we have $70 \times 32 = 2\,240$ square feet for the heating surface. 2. What heating surface and grate surface should be allowed for a triple expansion engine 3x4½x two 4⅝ inch cylinders, stroke 3 inches, running at the rate of 500 revolutions per minute, steam pressure 200 pounds? I have allowed 55 square feet of heating surface; is this enough? What will be the horse power of this engine, condensing? *A.*—This engine will develop about 15 indicated horse power. Allowing 3 pounds of coal per horse power per hour, the amount burnt per hour will be 45 pounds; allowing 15 pounds per square foot of grate, $\frac{45}{15} = 3$ square feet of grate surface will be required. For the heating surface, we have $3 \times 32 = 96$ square feet. These surfaces are suitable for soft coal.

(366) E. E. P., Jeffersonville, O., asks: What is the pressure on a piston of an 8x11-inch cylinder, the boiler pressure is 100 pounds per square inch, and follows full stroke? *A.*—The pressure in the cylinder is generally a little less than the boiler pressure. Assuming that the pressure in the cylinder is 95 pounds per square inch, then the pressure on the piston is found by multiplying the area of the piston in square inches by 95 pounds, which gives on a piston 8 inches diameter a total pressure of $50.26 \times 95 = 4{,}774.7$ pounds. This holds true only for that side of the piston which does not lose any of its effective area by that of the piston rod. To find the area of that side of the piston from which the piston rod projects, subtract the area of the piston rod from the area of the piston, and multiply the remainder by the steam pressure per square inch as before, the result will be the pressure on the piston. 2. Could a one horse power steam engine raise an iron ball weighing 1,000 pounds when the connecting rod is attached directly to the drum instead of the crank disk? *A.*—This depends on the relative speeds of the piston and the weight raised. A one horse power engine can lift a weight or ball of 33,000 pounds 1 foot high per minute, or a ball of 1,000 pounds through a distance 33 feet per minute. Hoisting machines are generally geared so as to give the piston a much greater speed than that of the load; if now in such cases the gears are thrown out and the connecting rod is attached directly to the drum, the engine will not lift as great a load as when geared, for the simple reason that the speed of the engine remaining the same in both cases, the speed of the load will be increased, and consequently the weight of load must be decreased. An engine running at a given speed and under a given steam pressure will develop a certain amount of horse-power, and this is always equal to the result obtained by multiplying the load in pounds by the distance in feet through which the load is lifted in one minute, and the product divided by 33,000, with proper allowance made for friction.

(367) M. M., Tamaqua, Pa., asks: What is the maximum safe load on a steel beam 30 feet long, supported at the ends, load in the middle? The beam is 15 inches deep, and weighs 80 pounds per foot. It must stand jars. *A.*—Unfortunately, you do not give the form of cross-section of the beam, but we shall assume it to be an I-beam. The load which such a beam can safely support is computed by the following formula:

$$W = 4 \times \frac{S \times I}{l \times c}, \qquad (1)$$

in which W = load in pounds, l = distance between supports in inches, c = one half depth of beam in inches, S = maximum fiber stress = 16,000 per square inch, and I = moment of inertia about an axis perpendicular to the web at the center; the value of I is generally given in list of beams or pocket companions furnished by the manufacturers; you will probably find that the value of I corresponding to this size of beam is 758. Substituting these values for the symbols in the formula, we have

$$W = 4 \times \frac{16\,000 \times 758}{360 \times 7\,5} = 17{,}964 \text{ pounds.}$$

From this load one half of the weight of the beam must be deducted, the remainder will be the safe neat quiescent load which the beam can support; this gives us $17.964 - 1.200 = 16\,764$ pounds, or 8 382 tons for the neat load. For steel beams subjected to shocks not over $\frac{1}{2}$ of this load should be taken. It is also assumed in these computations that proper provisions have been made for preventing the compression flanges of the beam from deflecting sideways. They should be held in position at distances not exceeding twenty times the width of the flange, otherwise the load as computed should be reduced. You should also have stated the purpose for which the beam is to be used, as the deflection under the computed load may be greater than is admissible by the conditions imposed. For a beam with a rectangular cross section formula (1) may also be used, by giving the proper value for I. For beams of this kind the moment of inertia I is equal to $\frac{b\,d^3}{12}$, in which b = breadth of beam in inches, and d = depth of beam in inches. Substituting this value for I in formula (1), and remembering that $c = \frac{1}{2}d$ we have

$$W = 4 \times \frac{S \times b \times d^3}{l \times \frac{1}{2}d \times 12},$$

which reduces to

$$W = 4 \times \frac{S \times b \times d^2}{l \times 6}. \qquad (2)$$

From this formula (2) the load which a rectangular beam will support can be computed.

BUSINESS SPECIALS

Transient Advertisements 50 cents a line for each insertion under this head. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue.

Cleveland, Cleveland, Cleveland, Grant, p. 12.

Forming Lathes, Mer. Mach. Tool Co., Meriden, Ct.

Milling Machs. Kempsmith Co., Milwaukee, Wis.

Turret Drills, 6 spindles. A. D. Quint, Hartford, Ct.

"National" Lathe Chucks. Best made, page 15.

Pattern and Brand Letters. A variety of sizes and styles. Heber Wells, 157 William St., N. Y.

Selden Packing for stuffing box, with or without rubber core. Randolph Brandt, 38 Cortlandt St., N.Y.

Best Presses and Dies for all sheet metal work. Ferracute Machine Company, Bridgeton, N. J.

Air Compressors for every possible duty. Clayton Air Compressor Works, 26 Cortlandt street, N. Y.

Guild & Garrison, Brooklyn, N. Y., manufacture steam pumps, vacuum pumps, vacuum apparatus, air pumps, acid blowers, filter press pumps, etc.

Split Pulleys at low prices, and of same strength and appearance as Whole Pulleys. Yocum & Son's Shafting Works, Drinker St., Philadelphia, Pa.

Improved Duplex and Special Gear Cutters in stock and to order; Gear and Milling Cutters of all descriptions. R. M. Clough, Tolland, Conn.

"Pumping Machinery." New book. 450 pp. 8vo, 270 Eng. Prospectus free. W. M. Barr, 3223 Powelton avenue, Philadelphia, Pa.

New Jersey Art Metal Co., Passaic, N. J., finest thin and ornamental castings in brass, bronze, aluminum, etc.; machinery name plates in brass and aluminum.

Grinders' Supplies—Emery, emery wheels, grinding machines, knife powders and sharpeners, paste and liquid polish, whetstones, etc., etc., quick process and large stock. Customers annoyed by the delays due to long processes and small stock can get goods in a hurry by buying of The Tanite Co., N.Y. City, Cincinnati, O., and Stroudsburg, Pa.

"Binders" for the AMERICAN MACHINIST. Two styles, the "Common Sense," as heretofore sold by us and mailed to any address at $1.00 each, and the "New Handy," mailed at 50c. each. The former has stiff board covers, while the latter has flexible covers with full page opening flat. Either will hold the entire 52 issues of any volume. AMERICAN MACHINIST PUBLISHING CO., 203 Broadway, New York.

The Manufacture of Very Accurate Straight-Edges.

BY F. L. O. WADSWORTH.

In the construction of mechanical or scientific instruments of precision, the problem frequently arises to provide means of guiding carriages through a considerable distance in as straight a line as possible.

Rectilinear motion may in general be secured by the employment of either link work or by the use of gibs or ways; but of these two methods the latter is by far the one more frequently adopted.

In the construction of the large "wave comparer," which has recently been used with such great success by Professor Michelson in his determination of the standard meter in terms of the wave length of light,* this same problem was presented, and the accuracy of movement demanded was considerably greater than is usually attained, even in the best comparators and measuring machines.

In this case the employment of link work was rendered impossible on account of the limited space at disposal, even granting that its employment would have secured the desired accuracy. The use of planed ways on the bed of the instrument itself, which in its general features resemble a long lathe bed, was equally inadmissible, because even if such ways could once be brought to the degree of straightness demanded, the initial strains in the casting would soon manifest themselves to such a degree as to render a re-surfacing, or rather a re-straightening, of the ways necessary whenever the bed was moved. For these and other reasons it was finally determined to secure the desired accuracy of movement by the use of steel straight-edges as guides for the carriages; these straight-edges forming no part of the bed itself, and being secured to it in such a way as to avoid as far as possible any distortion from a twisting or warping of the support.

The manner in which this was done is shown in Fig. 1, which shows the bed in cross-section. The main portion of the bed *a a* is of H section, and has planed upon it two ways, *r r*, on which the outer edges of the two carriages *M N* rest and slide. On the central cross bar of the H rests a long cast-iron bar *b*, against which are lightly clamped the three steel blades *c c' d*, four edges of which, viz., the two edges of the horizontal blade and the two upper edges of the two vertical blades, form the inner ways for the carriages *M*, *N*, which move longitudinally along the bed, and are therefore guided in their movement by the two planed ways *r r* on the bed and the steel straight-edges just referred to, the carriages being kept against the two vertical edges of *d* by the action of the inclined ways *r r*.

The actual problem was not, as might have been inferred from the preliminary statement of it, to have every point in the carriage move in a straight line; this would have necessitated that the outer ways *r r* be of the same order of accuracy as the straight-edges, and this even if once secured would have been extremely difficult to preserve; but it was to have the carriage so guided that the plane of section perpendicular to the line of movement should always remain parallel to a given fixed plane, or in practice so that a mirror supported on the carriage with its face in this plane should always remain as nearly as possible normal to a ray of light whose direction is parallel to the direction of movement.

Now, it is evident from this disposition and arrangement of bearing surfaces, that any irregularity or want of straightness in one of the ways *r r*, will produce simply a rotation of the carriage in a plane perpendicular to the line of intersection of the planes of the two edges, and that granting only that each of these edges be straight any surface mounted on the carriage parallel to this perpendicular plane will remain parallel to itself for all positions of the carriage. It is not necessary, either that the ways *r r* be straight or parallel to the

* *Nature*, 49, 60.

straight-edges, or that these last be parallel to one another.*

The problem, from a mechanical standpoint, then reduced itself to one of producing four straight-edges, of such an order of accuracy that the extreme angular movement of the carriage in moving from one end to the other of its ways should not exceed two seconds (2″) of arc, which means in linear terms that the error in any part of the straight-edge should not be greater than $\frac{1}{1500000}$ the length of the carriage (in this case seven inches), or about $\frac{1}{150000}$ of an inch. Although this was a rather high degree of accuracy for such long straight-edges (51½ inches), it was hoped that the manufacturers would be able to make them of the required degree of accuracy by ordinary mechanical processes. After considerable correspondence, the work was intrusted to a well known Eastern firm, whose reputation for this class of work is unexcelled in either this country or in Europe. In order, however, to check the results obtained by the manufacturers, as well as to afford a means of testing the edges after they were secured in place and at any future time during the use of the instrument, it was necessary to devise a method by which the edges might be compared with another standard edge; such, for example, as an actual metal standard, or a mercury surface.

The construction of another standard especially for this purpose involved considerable expense, which it was desirable to avoid.

Besides, in order to insure that this reference standard itself retains its form to this degree of accuracy in all positions of its use, it would have been necessary to have made it too deep and stiff to have been conveniently used in the space between the vertical edges and the sides of the bed. The two horizontal edges, c, c', might have been compared with a mercury surface by the aid of a high power microscope, a method used by Professor Rogers in surfacing the bed of the Rogers Bond comparator, but it is difficult to devise any simple method for comparing a vertical edge with such a horizontal surface.

The method, proposed by Professor Michelson and used first in the process of examination and afterward, during the process of grinding, for measuring the errors of the edges and checking the grinding process, is an optical one, which has been found more convenient in practice and capable of giving more accurate results than the methods of this character which have heretofore been used. It is to the improved method of testing rather than to any improved method of working that the results which have been obtained are due, for in any method of working in which corrections are determined and applied with reference to a standard edge or standard surface, the accuracy of the result cannot, as a rule, exceed the accuracy of the standard. In this case the reference edge, if such it may be called, which is used as a standard, is as near a geometrical straight line as it is possible to approach by any physical method, being what is termed a ray of light in the language of geometrical optics.

More explicitly stated, the method consists in projecting a parallel beam of light normally on the surface of a mirror, mounted on a carriage, which slides along the edge to be examined (the mirror being placed as nearly as possible at right angles to the edge), and measuring the angular deviation of the reflected beam as the carriage is moved along the straight edge.

The actual apparatus which was employed for the purpose is shown in Fig. 2. Light from the illuminated cross wires of an ordinary telescope, focused for parallel rays, falls upon a plane parallel piece of glass B, by which a portion is reflected to the mirror C, mounted on the testing carriage, and forms, after nearly normal reflection from this mirror, an image of the cross wires at the focus of the observing telescope D, also carefully focused for parallel rays. D is furnished with a micrometer eye-piece with double cross wires of the usual construction.*

a is an ordinary condensing lens, serving to concentrate the light from a lamp or gas flame on the cross wires of A.

Both telescopes being accurately focused for parallel rays, and the telescope D being set so that its axis is in the prolongation of the straight-edge under test and perpendicular to the mirror c, the glass plate B is adjusted until the illuminated field of A is central in the eye-piece of D.

The telescope A and the micrometer eye-piece are then rotated until the cross wires of each are parallel to the plane of the edge to be tested. The carriage is then placed at one end of the edge, and the wires of D set so that they are just bisected by the image of the horizontal cross wire of A.

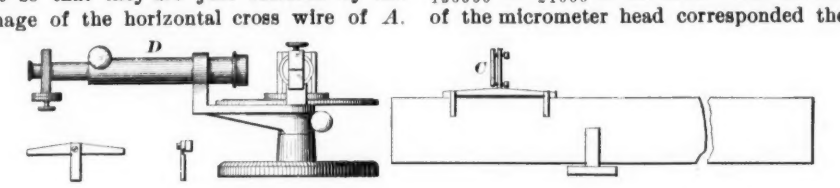


Fig. 2

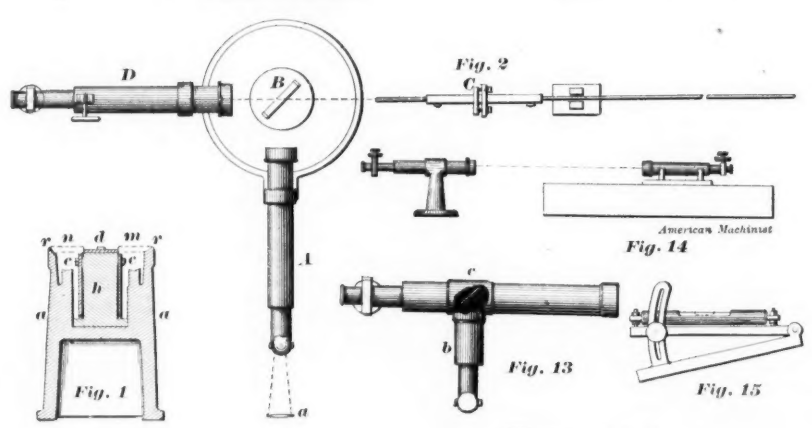


Fig. 1

Fig. 13

Fig. 14

Fig. 15

Fig. 3

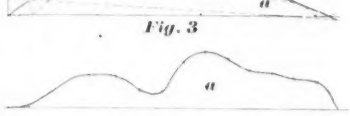


Fig. 4

Fig. 5

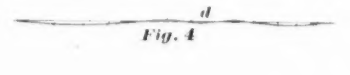


Fig. 6

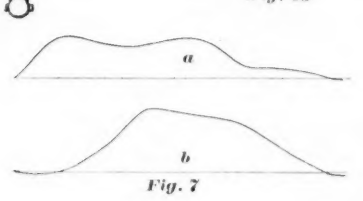


Fig. 7

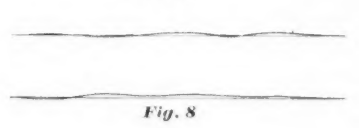


Fig. 8

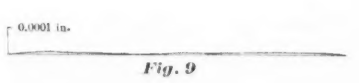


Fig. 9

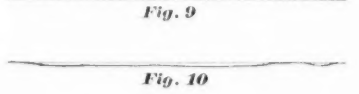


Fig. 10

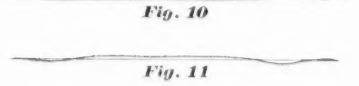


Fig. 11

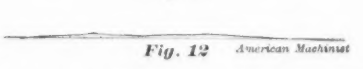


Fig. 12 American Machinist

Then if the edge be perfectly straight it is evident that the relative position of the micrometer wires and this image seen by reflection from c will remain the same for all positions of the carriage, but that any elevation or depression will at once cause a deflection of the image, the amount of which is accurately measured by the micrometer. The possible delicacy of the method is limited only by the size of the telescopes employed, provided only the mirror c be of the same size as the object glasses.

An objective of quite moderate size is, however, sufficient. The dimensions and constants of the apparatus used in the present case were as follows:

Aperture of telescope .....40 mm. (1.6″)
Focal length of telescope.....314 mm. (12.3″)
Constant of micrometer, 1 div. corresponds
.... to $\frac{1}{250}$ mm.

A deflection of the image through a distance of $\frac{1}{250}$ mm. at the focus of the observing telescope, corresponding to one division of the micrometer head, meant, therefore, an angular deflection of the beam of light of 3.2″, and, therefore, since the deflection of the beam of light is doubled by reflection, an angular deflection of the carriage and mirror through about 1½ seconds (1½″)

This constant can be and was measured directly in at least two other ways: (1) By inserting a strip of mica of measured thickness under one end of the carriage, and measuring the deflection produced, and (2) by displacing the cross wires of the first telescope through a known angle by means of the divided circle of the spectroscope table on which it was mounted, and measuring the corresponding deflection. The mean angular value (for the carriage) for one micrometer division, as found by all these methods, was for the apparatus used about 1.5″, corresponding to a displacement of one end of the carriage through about $\frac{7}{1500000} = \frac{1}{214000}$ of an inch. One division of the micrometer head corresponded then to about the limit of accuracy imposed. The resolving power of the telescope employed was such that differences of at least one fourth this amount could be measured with certainty;* indeed, readings were always made to tenths of a division, two successive readings rarely differing by more than 0.2 div. from one another.

A fairly typical set of readings taken during the process of grinding one of the edges is given in the following table. Here the two readings corresponding to the same position of the carriage were not taken successively, but form two of a continuous set, beginning with No. 1, and ending with No. 14, according to the method of testing, presently to be described. Added to the error of reading we have then the errors due to accidental particles of grit getting under the carriage between two readings, the error, if any, due to the movement of the carriage in opposite directions, and the error due to systematic changes in any part of the observing apparatus.

When the bar was approaching completion considerably greater care was taken in cleaning the surfaces before testing, and the results were then considerably better; for comparison a set of readings under these more careful conditions of testing is given in Table II., which shows that we may rely on the correctness of the indicated error to at least 0.1 div., that is to about $\frac{1}{2500000}$ inch.

When the finished straight-edges arrived, each one was set up with its edge horizontal, being supported in position by two wooden supports, as shown in Fig. 2, placed about one-fourth the length of the bar from each end. One of the four inch straight-edges, No. 1 (Fig. 1 c), was first tested and was found to fall so far below expectations that we determined to attempt the correction of it ourselves by grinding down the edge with fine emery. Three grinding tools were therefore prepared, of the form shown in Fig. 2 A, of different lengths, one being about 12 inches long, another 7 inches, and the third about 3 inches long. For the purpose of approximately determining the amount removed, a fine micrometer screw, with a large divided head, reading to $\frac{1}{1000}$ mm. $= \frac{1}{2500000}''$ was mounted so as to be used as a beam caliper, but it was found that after a little practice with a given grade of emery it was possible to judge very closely of the amount removed by the time of grinding and the pressure used. Besides the process of testing is so rapid that the whole operation of observing, reducing results, and plotting the curve requires on the average less than 10 minutes, and it is therefore better to determine the complete curve for the edge after each grinding. The routine method of doing this was as follows:

The carriage was placed first with one end coinciding with the end of the straight-edge, and the reading of the micrometer taken; it was then moved forward its own length and another reading taken, and so on to the end. A similar set was then taken going in the reverse direction, and the mean taken of the two readings (going and coming) for the same position of the carriage, as has already been indicated in Tables I. and II.

From this set of means the curve was plotted as follows: The difference between each reading and the next successive one, when multiplied by a factor depending on the constant of the micrometer and the length of the carriage, will evidently represent the difference in level between the two ends of the carriage in the second position, as referred to the line of reference, viz., the direction of propagation of the incident beam of light. If then these differences be successively added and the numbers so obtained plotted as ordinates to a curve whose abscissæ are distances along the straight edge, the resulting curve will be that of the edge in question. For convenience in plotting, the differences are taken not between successive readings beginning with the first (although this was the plan first adopted), but between each reading and the general mean, the object being to make the ends of the bar coincide with the axis of plotting, and at the same time furnish a check on the numerical reduction of the observations. The following set of readings, Table III., will serve as an example of this method of reduction, the readings being those made on the first straight-edge tested (No. 1), just as it came from the makers.

As seven inch intervals on the bar are too great for accurately determining its form, an intermediate set of readings was then

*A slight error is introduced on account of the finite width of the edges themselves, and the finite length of the bearing points, the bearing surfaces on the carriages being each about fifteen millimeters long, and of a width equal to the thickness of the straight-edge; but the errors introduced by this cause are of the second order, as compared with the necessary irregularities in the ways themselves.

*For the sake of avoiding confusion in the measurement it is a good plan to cut out the ordinary fixed wires, and retain only the double movable ones.

*Resolving power as ordinarily used is defined by the relation $\epsilon = \lambda/\Delta$ where ϵ is the smallest angle which can be "resolved," or the angle as viewed from the objective between two fine lines or points so close together as to be just distinguished apart; λ the wave length of light, and Δ the diameter of the objective. In this case $\epsilon = \frac{.00055}{40.5} = 2.5''$, a quantity considerably greater than it was stated it was possible to distinguish. It must be remembered, however, that it is easier to distinguish differences between two successive positions of a single object than to determine whether two bright objects placed close together are separate or no , because in the one case there are two sets of diffraction fringes which overlap and cause confusion, and in the other case only one set whose position has only to be judged with reference to some fixed object (in this case the cross wires) so far distant from it that no overlapping and consequent confusion results.

taken, beginning at a distance from the end equal to one-half the length of the testing carriage. This set, repeated in return as for the first set, was then reduced independently in the same manner and plotted with the first. As the second series of points so obtained is not necessarily referred by the process of reduction to the same axis of abscissæ as the first, it is generally necessary to adjust the second set with reference to the first, either by an elevation, depression or rotation of this axis. Usually a simple inspection would show which of these three operations was necessary.

For example, in the case of the bar just cited the readings at the intermediate points were as given in Table IV.

This series of points is plotted in Fig. 3, together with those of Table III.

If the curve were drawn through both sets of points at once as they stand, it would present a series of waves of regular period (as shown by the dotted curve) which there is no reason to suppose exist.

If we simply rotate the second system of points about the point a, we find that every point of the second system will fall nearly upon the curve drawn through the first set, the outstanding differences being such as we might readily suppose to exist.

The most probable general form of the edge as determined from these two sets of observations, at three and one-half inch intervals may, therefore, be considered to be represented by the heavy line, Fig. 3. It would, perhaps, be better to use a carriage only as long as the shortest testing interval, were it not for the fact that in the first stages of the correction it is not necessary to take intermediate points, and the process of testing at seven inch intervals is much more rapid than that at three and one half inch intervals with the shorter carriage. It would be best for this reason to have two carriages, one, say, of seven, the other of three and one-half inches length, the former to be used in the first stages and the latter in the final stages of the testing. The shorter the carriage, too, the greater the accuracy attainable with a given size of mirror and telescope. Although the shortest interval at which observations were plotted was three and one-half inches, the observations were in a sense continuous from one end of the bar to the other, for the motion of the carriage was so smooth that the motion of the image in the micrometer eye piece could be observed during the motion of the carriage. If any sudden deflection was observed between two points of observation, that particular part of the edge was always subjected to an examination at much shorter intervals.

The method of grinding, however, was such that the introduction of any irregularities of short period was extremely improbable, and, in fact, except in a few exceptional cases, such sudden changes were never observed.

The general process of grinding down the edge was to select (after each test had been made) a grinding tool corresponding to the character of the irregularity and a grade of emery corresponding to the amount to be removed, and grind away at the high places a length of time depending on the judgment of the operator. The edge was next very carefully cleaned by first washing thoroughly with coal oil or benzine, polishing with a piece of fine crocus cloth to remove any edge burr that might have been raised during the grinding, and finally rubbing the surface with a piece of linen or, better, chamois cloth. The bearing steps of the testing carriage were also carefully cleaned and the carriage placed in position and passed back and forth from one end to the other several times until not the slightest feeling of grinding or roughness due to any minute remaining particles of emery or dust could be detected.

When properly cleaned and polished the carriage ought to "float" on the edge almost as easily as one well-made surface plate on another. When this cleaning is properly performed the readings "going" and "coming" for the same position of the carriage agree with each other and may, as already stated, be depended on to 0.1 div. of the micrometer head.

The process of working down the edge by this process, successively testing and grinding, is very rapid, provided the material of which the edge is made is uniform and homogeneous, and, what is still more important, free from initial strain due to hammering or rolling. The characteristic successive steps in working down the edge first taken are shown in Fig. 4, a, b, c, etc., the final stage being represented in Fig. 4, d, an inspection of which will show that the maximum error remaining was less than $\frac{1}{25000}$ inch, an error considerably less than the limit imposed.

This was so encouraging that the remaining edges were corrected in the same manner.

Edge No. 3, the next one taken in hand, is represented in its initial state in Fig 5. As will be seen, it was considerably better than edge No. 1, but that the errors were considerably larger than could be allowed. In the process of working down this edge an unexpected difficulty presented itself—a difficulty due probably to a want of proper annealing of the steel bar of which the straight edge had been made. During the grinding the bar changed its form repeatedly, the changes observed between two successive grindings being far greater than could have been caused by the simple removal of too great an amount of material at local places. Another curious thing was that the local grinding of a high spot seemed in many cases to increase rather than diminish the error at the point of grinding; in other words, the metal seemed to swell up under the action of the grinding tool. Then, after a series of successive attempts to reduce the "hump" with very little success, the material seemed suddenly to give way all at once, and a deep hollow was the result. The grinding down of the extreme ends was a matter of special difficulty, as the springing there was especially bad. It seemed almost impossible to attain as high a degree of accuracy in this case as in the preceding, and after spending a good deal of time on the bar it was finally left in the state shown in Fig. 6, with the intention of making the final corrections after it had been clamped in place, hoping that the clamping might prevent the springing which proved so troublesome.*

The correction of edges Nos. 2 and 4, the opposite edges of the one bar c, proved the most difficult task of any. The warping, presumably on account of bad annealing, was specially bad, and working on either edge almost invariably affected the form of the other, so that it was necessary to reach the final result by a series of successive approximations, working first on one edge until it was nearly right, then on the other, then on the first again, and so on until the amount to be taken off from each side was so small that its removal did not affect its neighbor.

It was necessary also to make a specially light bronze testing carriage for this bar, in order to avoid errors due to the deflection of the bar by the weight of the carriage, errors for which it is true allowance might have been made, but which it seemed better to avoid if possible.

The deflection of the bar due to its own weight here becomes of importance †

It was reduced as far as possible by placing the supports about one fourth the length of the bar from each end, under which conditions the deflection at the center is only about one fortieth that experienced when the bar is supported at the ends. This slight outstanding error was in the first stage of the correction neglected, as it was intended to make the final correction *in situ*, thus eliminating at once all errors due to flexure. The initial curves for edges 2 and 3 are given in Fig. 7, the final curves in Fig. 8.

This work was mainly for the purpose of obtaining some idea of the capabilities of the method and determining the limit of accuracy which it was practically possible to obtain without too great an expenditure of time and labor.

TABLE I.

No.	Reading.	No.	Reading.	Mean of Two Readings for Same Position of Carriage.	Difference's from Mean.	Mean Error.	Probable Error of Single Setting.
1	14.7	14	15.0	14.85	.15	From 14 observations = .2 div.	As determined from 14 observations, $\epsilon = .61\sqrt{\frac{\Sigma\theta^2}{\sqrt{n-1}}}$ = .16 div.
2	15.3	13	15.0	15.15	.15		
3	15.6	12	15.2	15.40	.20		
4	14.1	11	13.5	13.80	.30		
5	15.0	10	15.0	15.00	.00		
6	13.7	9	14.4	14.15	.35		
7	14.0	8	14.6	14.30	.30		

TABLE II.

Edge No. 1, final.

No.	Reading.	No.	Reading.	Mean of Two Readings for Same Position of Carriage	Difference from Mean.	Mean Error.	Probable Error of Single Setting.
1	37.2	16	37.6	37.40	.20	Mean error of these 16 readings 0.07 div.	Probable error of single setting $\epsilon = .67\sqrt{\frac{\Sigma\theta^2}{\sqrt{n-1}}}$ = 0.06 div.
2	37.5	15	37.6	37.55	.05		
3	37.3	14	37.2	37.25	.05		
4	37.8	13	37.7	37.75	.05		
5	36.8	12	36.7	36.75	.05		
6	37.2	11	37.2	37.20	.00		
7	37.3	10	37.1	37.20	.10		
8	37.0	9	37.1	37.15	.05		

TABLE III.

No.	Position on Bar.	Mean "Going" and "Coming."	General Mean.	Difference	Σ differences = y.	$y' = .00007 \times y$ Difference of Level (Inches)
0	0	—	190.4 ÷ 7 = 27.2	—	0.00	.00000
1	7 inches	29.5	27.2	+ 2.3	+ 2.3	.00016
2	14 "	30.5	27.2	+ 3.3	+ 5.6	.00039
3	21 "	28.5	27.2	+ 1.3	+ 6.9	.00048
4	28 "	25.5	27.2	− 1.7	+ 5.2	.00036
5	35 "	25.8	27.2	− 1.4	+ 3.8	.00027
6	42 "	25.6	27.2	− 1.6	+ 2.2	.00015
7	49 "	25.0	27.2	− 2.2	+ 0.0	.00000
		190.4				

TABLE IV.

No.	Distance from End.	Mean of "Going" and "Coming."	Differences.	Σ Differences = y.	$y' = y \times .00007$.
0	3½"	—	—	000	.00000
1	10½"	29.5	+ 2.4	+ 2.4	.00017
2	17½"	29.5	+ 2.4	+ 4.8	.00034
3	24½"	27.8	+ 0.7	+ 5.5	.00038
4	31½"	25.4	− 1.7	+ 3.8	.00027
5	38½"	26.5	− 0.6	+ 3.2	.00022
6	45½"	25.6	− 1.5	+ 1.7	.00012
7	End	25.2	− 1.9	− .2	.00001

* It must be remembered that the movements observed are, after all, extremely small, the springing rarely amounting to more than .00005 inch, and usually much less.

† The deflection of a uniform bar supported at its ends is

$$\Delta = \frac{5}{32}\frac{s\,l^4}{E\,d^2},$$

where s is the weight of the bar per cubic inch, l the length (in inches) and d the depth. In this case assume $E = 25{,}000{,}000$. Δ is found to be .0027 inch, a quantity corresponding to about 50 div. of the micrometer.

As regards the first point a glance at the final curves will show that the extreme error for edge No. 1 was, as has already been stated, less than $\frac{1}{25000}$ of an inch, for edge No. 2 it was less than $\frac{1}{40000}$ of an inch, and for edge No. 4 about the same as for No. 2. In the case of No. 3, the error is considerably greater than this, on account of the special difficulties already mentioned. As regards expenditure of time, these results were reached in eight days (February 16th to February 24th), an average of only two days' work for each edge, which, for the degree of accuracy obtained, cannot be considered extravagant.

It was fortunate that no more time was spent in an attempt to secure a greater degree of accuracy, for the changes which the bars experienced either during the setting up of the instrument or during its transportation across the ocean, were very much greater than had been anticipated. A preliminary test of the straight-edges, after their arrival in Paris, showed that they were very badly warped, indeed, one of the edges being out nearly .0004 of an inch.

Notwithstanding the comparatively large amount of material which it was necessary to remove, it was determined to this time do *all* the grinding while the edges were firmly clamped in their final position, in hopes that this clamping might prevent the springing of the steel bars, which had before proved so troublesome, especially with edges Nos. 2, 3 and 4.*

The clamping screws having been screwed firmly down, a second test was taken, and showed that the form of the edges had not been materially changed by the clamping action. The testing carriages used were now the actual carriages to be used in the final work, a mirror being mounted on each one in such a way that any one of the four edges could be tested without moving the optical part of the testing apparatus. An innovation was introduced in the way of grinding tools, which was in many respects a step backward.

Instead of the iron grinding tools already described, a number of rectangular blocks of emery, of different lengths, and of varying degrees of fineness, were prepared. To protect one edge from the action of the grinding block while the adjacent edge was being worked upon, one side of the block was covered with paper.

The reduction of the large irregularities was performed by the mechanician of the laboratory, but in the final stages of the work it was found necessary to return to the iron grinding tools previously used.

After the edges had been brought to about the condition shown in Fig. 5, we took the grinding in hand ourselves, and in a few days, with the experience already acquired, brought the edges to their final condition, shown in Figs. 9, 10, 11, 12.

The difficulties encountered in this work were greater even than had been experienced in the course of the work on the free bars. In the first place, the initial strain in the bars was not allowed to manifest itself freely as before, on account of the clamping action of the screws, which was not, however, great enough to entirely prevent what seemed to be a gradual or often sudden "creeping," which proved very troublesome. Moreover, the work on any one edge was almost certain to affect the trueness of the adjacent edge, so that, in this case, all the edges had to be reduced by the process of approximation, which has already been referred to as necessary in the previous work, in case of edges Nos. 2 and 4, some of the individual steps of which were more satisfactory as regards a single edge than the final result for that edge. It is especially worth noting, however, that all, or nearly all, of the difficulties encountered were due to the bad material, or rather the bad state of the material, of which the bars were made. Had the steel been uniform in texture, and either thoroughly hardened

* The author is now of the opinion that if most of the material had been removed while the bar was free, many of the difficulties encountered in the final stages of the work would have been obviated.

and seasoned, or thoroughly annealed, the time required to complete the work would have been reduced one-half, and probably more. Even in the state of strain, however, there was no difficulty in reducing the errors of the edge to an order of $\frac{1}{50000}$ inch. An hour or two hours' work usually sufficed to bring about this order of accuracy when the initial error was from five to ten times this amount. The time taken to bring all four edges to their final state, as shown in Figs. 9–12, was between 40 and 50 hours, an average of from 10 to 12 hours' work on each edge. As will be seen by inspection, the accuracy is rather greater, on the whole, than was attained in the first work, the greatest absolute error for two of the edges, at least, being not greater than $\frac{1}{50000}$ inch, with a mean error of less than $\frac{1}{100000}$ inch in the whole length of 52 inches. To make a straight-edge of this length accurate to this degree, by the ordinary method, would require an expenditure of time which would render it impracticable as a commercial operation. The results of the preceding work, however, show conclusively that, with suitable material, such edges may be prepared from the planed bar at an expense (for labor) not exceeding $3 per foot of length for edges, four feet long, accurate to within $\frac{1}{50000}$ inch for their whole length.

For longer edges the cost would probably be somewhat less, for shorter ones somewhat more per foot of length. *There is no limit to the length which may be made straight to this order of accuracy quite without reference to any material standard,* an important consideration when it becomes a question of making standards six to ten feet in length.

Errors due to flexure are corrected in the process itself, it being only necessary that the edge be tested when supported in the same manner and the same position in which it is to be used. This allows the use of comparatively light bars instead of the deep girder forms necessary when the ordinary method of correction by working three edges to one another is used, a process which requires that at least two of the bars be stiff enough to avoid a perceptible change of form when turned upside-down, a condition very difficult to secure when the bars become of unusual length.

It is difficult to see what obstacles remain to be overcome in the successful application of this method to commercial work, except the single one of obtaining homogeneous and well tempered bars of metal upon which to operate. As has been seen, it is possible to produce straight edges of the order of accuracy herein stated rapidly and cheaply, even when the material is not properly prepared, but these edges are not sufficiently permanent under handling to warrant their being brought to such a degree of accuracy unless they are to be permanently clamped in place.*

Given a bar of proper material, it may be confidently stated that straight-edges of from five to ten feet in length, or even longer, if desired, may be produced with an error not exceeding $\frac{1}{100000}$ inch in their whole length. The same method may be applied also to the correction of the ways of measuring machines, dividing engines, comparators or any apparatus in which a very accurate rectilinear motion is to be secured. To these last purposes it is especially applicable, as it allows the testing to be made and the corrections to be applied in any desired position of the edges or ways upon which the work is being done, which renders it possible and practicable to always correct the ways when the bed which supports them rests in the position which it is destined finally to occupy, compensating then at once for all the effects of flexure due to want of rigidity, and twist or other distortion due to the manner of support.

To sum up briefly, the principal advantages which the method seems to possess are :

(1) Possibility of producing one edge, and one edge only, of any required length and of any required order of accuracy, without reference to any previously existing edge or material standard.

(2) The possibility of measuring definitely the errors in this edge and mapping them for future reference, so that it will not be necessary to carry the work on any edge further than the desired order of accuracy.

(3) Ability to test and correct an edge in any position, and to readily verify its correctness at any future time, re correcting it if necessary without removing it from position.

(4) Rapidity and cheapness in securing a desired result.

This last is an important practical advantage which leads me to hope that the article may not be without interest to the intelligent mechanics and instrument-makers of this country, who are always ready to adopt any practical methods which will lead to greater accuracy in the production of certain classes of high-grade work.

A number of modifications of the general method which may prove serviceable in certain cases may be proposed. Those familiar with the optical arrangements will at once see that instead of two telescopes, arranged as shown with the glass B, all that is absolutely necessary is a single one, occupying the position of C, and provided with a pair of illuminated cross-wires, the image of which will be seen in the field of the eye-piece when the telescope is focused for parallel rays and the mirror is nearly perpendicular to the axis of the telescope. The deflection of the image from the cross-wire itself might be measured as before, or perhaps even more simply by the aid of a fine scale in the eye-piece. As it is desirable for the sake of accuracy to use a double movable wire to fix the position of the deflected image, and as it is also desirable to be able to move the set of wires whose image is observed without moving those in the micrometer eye piece, a better arrangement would perhaps be that shown in Fig. 13. Here the illuminated cross wires are placed at the end of a short tube b, placed at right angles to the axis of the telescope. At c, the intersection of the axis of b with the axis of the telescope, is placed either a plane parallel glass at 45 degrees covering the whole field, or a small right-angled prism covering one half the field. D, as before, is simply a condensing lens which serves to concentrate the light on the cross-wires in b. With this device the whole arrangement is rendered very compact and convenient to use, as both sets of wires are close to the observer. Means might easily be provided by which the observer could himself move the carriage along the bar to any desired position without leaving his seat ; but as the one who is doing the grinding is always at liberty during the operation of testing, the necessity for such a device is obviated.*

For horizontal edges and ways, a somewhat simpler method may sometimes be used. Instead of measuring the deflections of the testing carriage optically, they are measured by means of a delicate level which is secured to it. Level bubbles can now be obtained so sensitive that one division on their scale corresponds to one second, and as one-half a division is easily read with

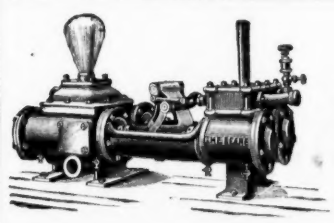
* There has been no perceptible change in the edges since they were first finished, which, at the date of writing, was over six months ago, during which time the instrument has been in use almost continuously.

* It is usually best to have two persons in doing the work, one of whom attends to the grinding, the other to the testing. One observer, however, can easily test as rapidly as three or four can grind.

The usual method of optical testing is to place a telescope on the carriage which moves on the straight-edge, and direct this telescope either at a very distant object, or better, at the cross-wires of a second collimating telescope placed in line with the straight edge, as shown in Fig. 14

We can then observe in either telescope (their axes being now in the same straight line) the movement of the image of the cross-wires of the other as the carriage is moved along.

The primary disadvantage of this method is that it makes the testing carriage much heavier than the mirror does, a very serious objection when great accuracy is demanded. Then, for a given size of telescope it is only one half as delicate as the mirror method, as the angle through which the image is deflected is, in this case, the same as that of the carriage, instead of double that angle as in the case of the mirror method.



THE DEANE
OF HOLYOKE
STEAM PUMPS
DEANE STEAM PUMP CO.,
HOLYOKE, MASS.

CRESCENT STEEL
ESTABLISHED 1865 ✻ INCORPORATED 1889.
CRESCENT STEEL CO.
480 PEARL ST. NEW YORK — PITTSBURGH, PA. — 64 & 66 S. CLINTON ST. CHICAGO.

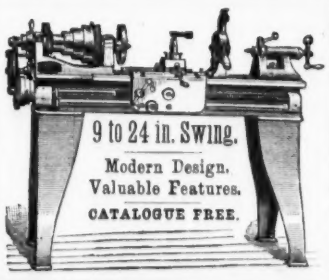
"LIGHTNING" SCREW PLATES IN
Birmingham ("Stubs") Wire Gauge Sizes,
SCREW GAUGE SIZES AND SIZES IN FRACTIONAL PARTS OF AN INCH.
For BICYCLE REPAIRERS, ELECTRICIANS and others.
Adjustable Dies with Case-hardened Guides.
Send for Supplement No. 1.
WILEY & RUSSELL MFG. CO.,
GREENFIELD, MASS., U. S. A.

PRESSURE REGULATORS
FOR STEAM, WATER OR AIR.
Our regulating devices are standard all over the world, and if you wish any kind of Regulator for any purpose, write us.
MASON REGULATOR CO.,
BOSTON.

"R. MUSHET'S SPECIAL STEEL"
SAVES LABOR in being able to run at GREATLY INCREASED SPEEDS. FEWER GRINDINGS. No WASTE in redressing.
SOLE REPRESENTATIVES IN THE UNITED STATES.
B. M. JONES & CO.,
BOSTON: 11 & 13 Oliver St., NEW YORK: 143 Liberty St.

BUFFALO BLOWERS,
UNEQUALLED EFFICIENCY, DURABILITY, MINIMUM POWER.
BUFFALO FORGE CO. BUFFALO, N.Y. U.S.A.

BUFFALO BLACKSMITH TOOLS.
PUNCHES, SHEARS, DRILLS, HAND BLOWERS, FORGES, ETC.
BUFFALO FORGE CO. BUFFALO, N.Y. U.S.A.



LATHES! PLANERS!! SHAPERS, &c.!!!
We Were Not Awarded a Medal at the World's Fair,
because our tools were not on exhibition there but our customers write us that every tool built by us has proven exactly as represented. Our claim is that "Our tools are of the latest and most approved designs, while the workmanship, material and finish are of the highest order." Our catalogue will tell you all about them. Prices quoted on application. No time like the present to buy!
SEBASTIAN LATHE CO.,
117-119 Culvert St., CINCINNATI, O.

GRANT GEARS
CLEVELAND
86 SENECA ST.,
Near Union Depot.
NEW GEAR SHOP.
GEO. B. GRANT.

THE GAS ENGINE,
History and Practical Working,
BY DUGALD CLERK.
With over 100 engravings. 12mo, cloth. $2.00.
JOHN WILEY & SONS, NEW YORK.

SECOND-HAND MACHINE TOOLS
FOR SALE AT LOW PRICES.
50 Driving Wheel Lathe. N. Y. S. E. Co.'s make. Fair order.
36" x 36" x 10' Sellers Planer, single head. Good order.
34" x 8½' Putnam Engine Lathe, rod feed, screw and compound rest. Good order.
26" x 8' Pratt & Whitney Chucking Machine. Very good order.
12" x 4' Pratt & Whitney Engine Lathe, with taper attachment.
1 Pratt & Whitney "Grant Pattern" Double Column, Double Head Milling Machine. Good as new.
2 22" Pratt & Whitney Manufacturers' Drills, with two-spindle attachment. Good order.
E. P. BULLARD, 145 Broadway (Room 6), New York.
BRIDGEPORT MACHINE TOOL WORKS, BRIDGEPORT, CONN.

H. W. JOHNS'

ASBESTOS SECTIONAL PIPE COVERINGS.
NON-CONDUCTING COVERINGS FOR STEAM AND HOT WATER PIPES, BOILERS, ETC.
ASBESTOS BOILER COVERINGS.
H. W. JOHNS MANUFACTURING COMPANY,
H. W. Johns' Asbestos Millboard, Sheathings, Building Felts, Fire-Proof Paints, Liquid Paints, Asbestos Roofing, Etc.
87 MAIDEN LANE, N. Y.
JERSEY CITY. CHICAGO. PHILADELPHIA. BOSTON. LONDON

certainty, it follows that for a carriage of the same length deflections nearly as small as those measured optically may be determined more directly in this manner.

By mounting the level as shown in Fig. 15, it would be possible to examine edges inclined at any angle in a vertical plane; but as the method is a gravitational one, it fails for all edges out of this vertical plane.

Aside from its applications to the mechanical operations already indicated, the optical arrangement described in this paper would be admirably adapted to the experimental investigation of certain problems connected with the theory of elasticity.

Formulæ for the elastic curves of beams and columns under different conditions of loading have been worked out for a great many cases, but as far as I am aware, no complete experimental verification of any of these formulæ has been made.

Such a verification, aside from its interest on purely theoretical grounds, affords data for the determination of E, the coefficient of elasticity. This coefficient is often obtained by measuring the bending of a bar supported at the ends by a considerable weight supported at the center, the deflection due to the weight being measured by the aid of a micrometer microscope. This method involves the use of quite as much apparatus as the one which is here proposed, and which gives us, in addition to the absolute deflection at the center, knowledge of what is going on at all parts of the length. —*Journal of the Franklin Institute.*

MANUFACTURES.

The West Silver Works at Taunton, Mass., started up recently.

The Berlin, N. H., Mills Co. has commenced to erect a new pulp-mill.

The General Electric Co., Lynn, Mass., is working about 1,400 hands.

The Sterling Steel Works, at McKeesport, Pa., has resumed operations.

The Portland (Ore.) Cable Railway Company will adopt electric motive power.

The capital stock of the New Haven (Conn.) Brass Goods Co. has been increased.

A planing-mill will be built at Pine Bluff, Ark. About 100 men will be employed.

The Howard Plow Co. has been formed in Lamar, Mo., with $50,000 capital.

The Rome City (N. Y.) Street Railway Company will adopt electric motive power on its system.

The Schneider Permutation Lock Co. has been formed at Galena, Ill., with a capital of $25,000.

The Hillsboro (Tex.) Investment and Electric Company will erect an electric-light and power plant.

The Nashua Iron and Steel Company, of Nashua, N. H., is to start its steel mill in a few days, or as soon as needed iron and coal can be secured.

Manager T. C. Page, of the Lamb Manufacturing Co., Chicopee, Mass., has opened the bids for the new building, and the contract for the wood-work was given out.

C. H. Cowman and others have incorporated the Snowden & Cowman Manufacturing Co. in Baltimore, Md., to manufacture engines, elevators, etc. The capital stock is $40,000.

A report has circulated that the steel-mill at the Nashua Iron and Steel Co.'s plant, Nashua, N. H., would not start up as expected. The intention now is to start the steel-mill in a few days.

The Electric Heat Alarm Company, being obliged to have more factory and office room, have taken the lease of an entire floor at No. 145 High street, near Fort Hill Square, Boston.

The Ruddy Thread Company, of Worcester, Mass., will erect a 50x100-foot two story dye house with boiler house attached. A work room, drying room and counting room will be provided in the new building.

Wm. S. Doig, 24 Franklin street, Brooklyn, N. Y., is putting up a brick building for use as a machine shop on Franklin street near his present location. The building occupies two numbers on the street and will have several stories.

The new building of the Popes Island Manufacturing Co., New Bedford, Mass., are nearly finished and the two 80 horse-power boilers have been set. A brick stack 75 feet in height is to be built. The plant will be in operation in about six weeks.

Negotiations are pending between the Chicago Tin-plate Manufacturing Co. and the owners of a rolling-mill located near Chicago, whereby the former is endeavoring to obtain possession of the mill in order to roll its own black plates.

The Portland Wringer Company has been organized at Portland, Me., for the purpose of making and dealing in mop wringers, etc., with $100,000 capital stock. The officers are: President, William I. Alden, of Portland; treasurer, Robert E. Alden, of Portland.

To increase capacity the Clinton (Mass.) Wire Cloth Co. has begun the erection of looms in the new weave mills. The new mill is three stories high and contains three weave rooms 300x80 feet. The work will be pushed, and by the end of the week probably 100 looms will be in position.

Might & Miller, who recently purchased the plant of the Hollis Tack and Nail Company, at Scottdale, Pa., have had the plant completely overhauled, putting it in first-class working order. A number of machines have been put in operation and additional ones will be added in a short time.

The rail-mill of the Johnson Company, at Johnstown, Pa., has resumed operations. This is the only mill that will be removed to the new plant at Lorain, O. Its place will be taken by a department for the manufacture of an improved street-car truck, under a patent belonging to the company.

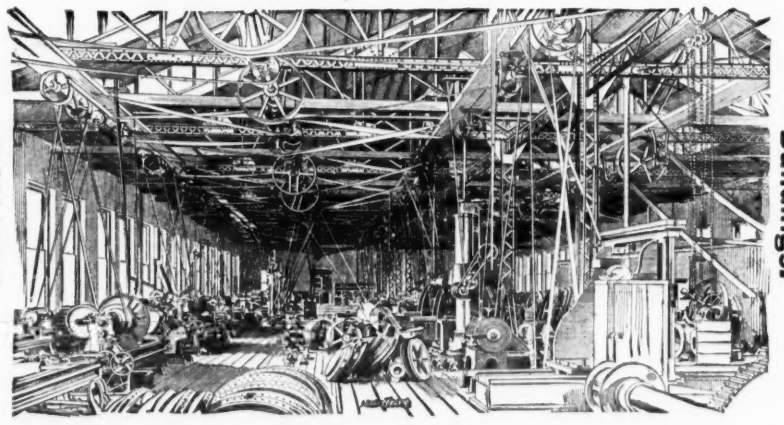
The plant of R. R. Howell & Co., Minneapolis, Minn., which was recently destroyed by fire, is now being rebuilt. They are adding considerable new machinery, among which is a 54 inch planer and a

DON'T ACCEPT ANY SUBSTITUTE FILE.
INSIST ON HAVING
NICHOLSON.

NICHOLSON FILE CO.
PROVIDENCE, R. I., U. S. A.
3000
VARIETIES FILES
[X. F.] & INCREMENT CUT FILES.

THE BERLIN IRON BRIDGE CO.
Office and Works,
No. 8 Railroad Ave., East Berlin, Conn.
CHAS. M. JARVIS, Pres. and Chief Engineer. BURR K. FIELD, Vice-President.
FRANK L. WILCOX, Treasurer. GEO. H. SAGE, Secretary.

Engineers, Architects and Builders of



Iron and Steel Bridges and Buildings.

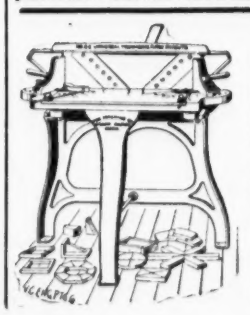
The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop, the Roof of which was designed and built by us for the Titusville Iron Co., at Titusville, Penn. The building is 70 feet in width by 205 feet in length. The roof trusses are made entirely of iron, and designed to carry shafting. Through the center of the building is a row of wrought iron columns. Machine shop roofs built after this plan are not only much neater in appearance than heavy, cumbersome, wooden trusses, but are stronger and stiffer; and where no wood is used about the construction the danger from fire is entirely eliminated.

SEND FOR OUR ILLUSTRATED CATALOGUE.

COOKE & CO.,
163 & 165 Washington Street,
NEW YORK.

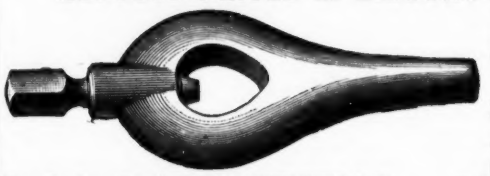
WATERS PERFECT ENGINE GOVERNOR.
Simplest and most sensitive.
WRITE FOR PRICE LIST AND MENTION THIS PAPER.

HENRY CAREY BAIRD & CO.,
INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS,
810 Walnut St., Philadelphia.
☞ Our New and Revised Catalogue of Practical and Scientific Books, 88 pages 8vo., and our other Catalogues and Circulars, the whole covering every branch of Science applied to the Arts, sent free and free of postage to any one in any part of the world who will furnish his address.



THE NEW FOX
Universal Trimmer
is the only one that has an accurate adjustment of the gauges. Cannot be set wrong. Work must be correct. Time saved in Pattern-making and all wood-working.
CATALOGUE FREE!
FOX MACHINE CO.,
325 Nor. Front St., Grand Rapids, Mich.
135 Finsbury Pavement, London, England.

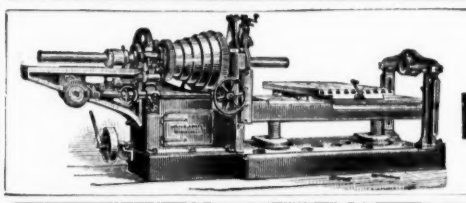
REDUCED PRICES OF LECOUNT'S STRAIGHT TAIL DOG.



To be driven from a Stud in the Face Plate.

No.	INCH.	PRICE.	No.	INCH.	PRICE.
1	3/4	$0.60	10	2 1/4	$1.35
2	7/8	.70	11	2 1/2	1.45
3	1	.70	12	3	1.60
4	1 1/8	.80	13	3 1/2	1.80
5	1 1/4	.80	14	4	2.10
6	1 3/8	.95	15	4 1/2	2.75
7	1 1/2	.95	16	5	3.25
8	1 3/4	1.10	17	5 1/2	4.00
9	2	1.20	18	6	5.00
1 Set to 2 in.		7.80	Full Set,		$1.10

These Goods are for sale by CHAS. CHURCHILL & CO., L't'd, 21 Cross St., London, England.
C. W. LeCOUNT, South Norwalk, Conn.

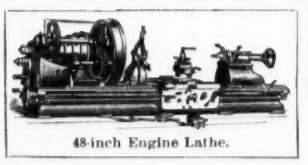


BETTS MACHINE CO.,
WILMINGTON, DEL.
MACHINE TOOL BUILDERS.
Improved Patterns! Late Designs!

$85
"Star" Foot Lathe Swings 9x25 in.
LATHE
Screw Cutting Automatic Cross Feed, etc.
Scroll Saws, Circular Saws, Lathes Mortisers.
Catalogue Free of all our Machinery.
Seneca Falls Mfg. Co., 687 Water St., Seneca Falls, N.Y.

JESSOP'S STEEL
FOR TOOLS, DRILLS, DIES, &c.
ALL KINDS IN STOCK.
Manufactory, SHEFFIELD, ENG.
Chief Am. Office, 91 JOHN ST., N. Y.
WM. JESSOP & SONS, LTD.
Established a century ago.
Medal World's Columbian Exposition 1893.

FITCHBURG MACHINE WORKS,
MANUFACTURERS OF THE CELEBRATED
FITCHBURG MODERN ENGINE LATHE
AND OTHER METAL-WORKING MACHINES
SEND FOR CATALOGUE E.



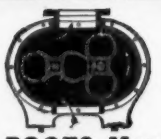
48-inch Engine Lathe.

FITCHBURG, MASS.

BUILDERS IRON FOUNDRY,
FOUNDERS AND MACHINISTS,
PROVIDENCE, R. I.
Orders are solicited for machine work requiring accurate workmanship and large machine tools. Our equipment is probably superior to that of any shop in New England, employed chiefly for contracts or general jobbing. Small, as well as large orders receive careful attention, and we are prepared to assist machine shops which have tools smaller than our own.

ROOT'S FORCE BLAST ROTARY BLOWER.
For FOUNDRIES, SMITH SHOPS, PNEUMATIC TUBES, VENTILATION, ETC.

SLOW SPEED, POSITIVE BLAST, PERFECTLY BALANCED.



BEST MECHANICAL CONSTRUCTION.
P. H. & F. M. ROOTS, Manufacturers,
CONNERSVILLE, IND.
Chicago Office: 1405-10 Manhattan Building.
S. S. TOWNSEND, Gen. Agent. } 163 & 165 Washington St., NEW YORK.
COOKE & CO., Selling Agents. }
In Writing Please Mention This Paper.

WORTHINGTON
PUMPING ENGINE
FOR
WATER WORKS.
SIMPLE, COMPOUND, OR TRIPLE EXPANSION, HORIZONTAL OR VERTICAL
HIGHEST DUTY GUARANTEED.
COMPLETE DESCRIPTIVE PAMPHLETS ON APPLICATION.
HENRY R. WORTHINGTON,
NEW YORK, 86 and 88 Liberty St.
BOSTON, 70 Kilby St.
PHILADELPHIA, 607 Arch St.
CLEVELAND, 24 South Water St.
CHICAGO, 185 to 189 Van Buren St.
ST. LOUIS, Eighth and St. Charles Sts.

30-inch lathe purchased from The Lodge & Davis Machine Tool Co., of Cincinnati, O.

The Detroit Twist Drill Co., of Detroit, Mich., feels constrained to warn the public against making or using the particular form of drill and drill holder covered by their patents. The company calls particular attention to patent No. 339,544 as setting forth their rights in the drill.

The Berlin Iron Bridge Co., of East Berlin, Conn., have received the contract from M. C. Henry & Co., of New York, N. Y., to cover their stone yard with an iron roof, and also for a traveling crane. Building will be 50 feet in width and 100 feet in length, constructed entirely of iron, the whole space to be controlled by the traveling crane.

The Pairpoint Mfg. Co., New Bedford, Mass., has increased its capital from $500,000 to $600,000, and has purchased the property and business of the Mount Washington Co. The business will be run with the name of the Pairpoint Mfg. Co., and will continue with the same management. Edward D. Mandell is president, and Thomas A. Tripp, clerk and president of the company.

A Philadelphia dispatch of July 24th says: The reorganization committee of the Pennsylvania and Maryland Steel Companies met here to-day and completed the plan for judicial sale, amicable adjustment having been abandoned. Over 90 per cent. of the creditors have assented to the plan. The time for subscriptions to the new preferred stock to the amount of $1,500,000 was extended to October 1st, and common stock will then be wiped out.

The A. Garrison Foundry Company, Pittsburgh, Pa., has received a contract from the Pittsburgh Tin-plate Works, of New Kensington, for the erection of a two mill plant. The firm will roll its own sheets for tinning purposes, instead of buying them, as heretofore. The new addition will be so constructed that two additional mills can be added at any time desired.

The Frank-Kneeland Machine Company, Pittsburgh, Pa., has just shipped two hot and two cold tin-mills to the Canonsburg (Pa.) Iron and Steel Company, also a set of cold rolls to the Reeves Iron Company, of Canal Dover, O. The same firm have the contract for the doubling and squaring shears for the 2-mill plant now being erected by the Pittsburgh Tin-plate Works, at New Kensington, Pa.

The Berlin Iron Bridge Co., of East Berlin, Conn., have received the contract from the Delaware, Lackawanna & Western Railway for one of their patent anti condensation corrugated iron roofs, to cover the new engine room at the Auchincloss shaft. This is the third roof of this kind that the Delaware, Lackawanna & Western Railroad people have bought of the Berlin Company, showing the positive merits of their system of protecting the corrugated iron on the underside from dripping.

George B. Grant, gear wheels and gear cutting, of Lexington, Mass., and Philadelphia, Pa., has fitted up a new gear shop in Kennard's block, No. 86 Seneca street, Cleveland, O., near the Union Depot and not far from the city square. It is under the management of William K. Bailey, who has been the superintendent of the Lexington shop for some years. It is fully equipped for making and cutting gears and fully stocked with ready-made gears. The object is to accommodate customers in the West better than is possible from the Eastern shops.

Machinists' Supplies and Iron.

New York, July 28, 1894.

Iron—American Pig—We quote standard brands, $12.50 to $13 for No. 1; $11 to $12 for No. 2. Southern brands, $11 50 to $12.25 for No. 1; $10.50 to $11 for No. 2; $10 to $10 25 for No. 3; $10.50 to $11 for No. 1 soft; and $10.25 to $10.75 for No. 2 soft. Foundry No. 4, $9.75 to $10 25.

Antimony—We quote L. X., 8¾c. to 8⅝c.; Cookson's, 9¾c. to 10c.; Hallett's, 8.25c. to 8.50c; and U. S. French Star, 10c.

Lard Oil—We quote 55c. to 57c., according to quantity.

Copper—The market is dull. There is scarcely any demand, as consumers are well supplied for their present wants. We quote Lake Copper at 9⅛c.; probably 9c. will buy. Casting Copper is held at 8.60c.

Lead—The market is unsettled and the demand light. For New York spot 3.55c. is asked.

Spelter—The market is dull without any signs of improvement. The quotations are 3.50c. for New York delivery.

Tin—The prices are barely steady, and there are scarcely any improvements. For spot 18.80c. is asked.

✲WANTED✲

"Situation and Help" Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Mechanical draftsman with 4 years' exp. and college education desires a position. S., Am. Mach.

An experienced designer of fine machinery wants position. Box 126, American Machinist.

Practical mech. draftsman wants position; 10 years' experience. M. D., American Machinist.

Have served 2 years at machinists' trade and want job in first-class engine shop to finish trade. Box 544, American Machinist.

Man experienced on printing and folding machinery; understanding character of same, design and manufacture, and capable of producing economically, seeks position. Artificer, Amer. Mach.

Wanted position in high school or college as instructor in pattern-making; 16 years' practical experience; thoroughly acquainted with loam work; good references. G. H. W., Amer. Machinist.

Mechanical engineer, American, 13 years marine and general land experience home and abroad, speaks German, Dutch, French and Spanish, acquired in Europe, desires position as manager foreman, instructor or erecter willing to go abroad, highest refs. Suverkrop, 59 State St., Camden, N. J.

✢ MISCELLANEOUS WANTS ✢

Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cheap 2d hd lathes & planers. S.M.York, Clev'd, O.

Auto. Steam Flue Cleaners. Kelley Co., Erie, Pa.

Calipers & Gauges. F. A. Welles, Milwaukee, Wis.

For Sale—Second-hand drill presses, engine lathes & planers. Dietz, Schumacher & Co., Cincinnati, O.

Light and fine machinery to order; Foot Lathe Catalogue for stamp. E. O. Chase, Newark, N. J.

Wanted—To buy good second-hand tools. Box 83, American Machinist.

Do you want a picture of the famous Locomotive "999?" Send 50 cents for our fine copper plate *transparent* picture (14x28), showing all parts *inside* and *outside*, all named and numbered, on satin gloss paper, for framing, educational, beautiful, correct. Locomotive Engineering, 256 B'way, N. Y.

CLEVELAND TWIST DRILL CO'S. GRIP SOCKETS. No More Twisted Tangs.

Larger drills can be used with smaller shanks than ever before. No charge for the groove in the shanks.

Send for Descriptive Price List.

Cor. Lake and Kirtland Sts., Cleveland, Ohio.

DETROIT TWIST DRILL CO., DETROIT, MICH., U. S. A.
SOLE MANUFACTURERS OF
GRAHAM'S GROOVED SHANK TWIST DRILLS AND CHUCKS.

Endorsed by Practical Mechanics Everywhere. Send for Catalogue.

SECOND-HAND MACHINE TOOLS,
Boiler Tools and Steam Hammers
Now remaining unsold in the Engine and Boiler Works, will be sold very low before removal.

IRON PLANERS.
19 in. x 3 ft. Wheeler.
20 " x 4 " Lathe & Morse.
24 " x 4 " Wood & Light.
24 " x 5 " New Haven.
26 " x 7 " N. Y. S. Eng. Co.
30 " x 10 " Pease
35 " x 7 " Hewes & Phillips.
36 " x 8 " Pease.
60 " x 24 " Heavy Pattern.

SHAPERS.
8 in. Stroke Gould.
16 " " Gould & Eber.
22 " " Triple Geared.

DRILLS.
25 in. Swing, Prentice, complete.
26 " " Prentice Friction.
40 " " Cinti, complete.
48 " " Old Style.
Radial Drill, 86 in. complete.

MILLING MACHINES.
Brown & Sharpe No. 6, Plain.
Brainerd No. 15, Universal.
Garvin No. 3 Bk. Gears auto. fd.

BORING MILLS.
Bement No. 2 Hor., B. & D.
Bement Cyl. Borer, for Cylinders 10 to 30 in.
Upright B. & T. Mill, 38 in.
Pond Upright B. and T. Mill 6 ft.
B. & S. Upright Turret Borer.

ENGINE LATHES.
11 in. x 5 ft. Phila.
13 " x 6 " Blaisdell.
14 " x 6 " Reed.
16 " x 6 " New Haven.
16 " x 6 " Ames.
18 " x 8 " Putnam.
20 " x 10 " Fitchburg.
22 " x 10 " Bement
24 " x 12 " Putnam.
30 " x 10 " Prentiss, Taper.
35 " x 15 " Hewes & Phillips.
36 " x 24 " Old Style 'cheap.'
36 " x 17 " Ferris & Miles.
48 " x 17 " Hewes & Phillips

HAMMERS.
50 lb. Helve, Bradley. Up'g't.
300 " " Steam, Ferris & Miles.
800 " "
1200 " Drop with Lifter, Farrel F'd'y's Make.

BOILER TOOLS.
Rolls, 6, 8 and 10½ ft.
Hor. Flange Punch, "H. and J."
Flange Clamps, 6 ft.
Bement Plate Planer, 16 ft.

MISCELLANEOUS.
Acme, 3½ in. Bolt Cutter.
Slotters 10 and 18 in. Stroke.
Putnam Tool Grinder.
Screw Machine, 2 in. hole.
Hand Jib Crane, "Cheap."
Allen Port Riveting Mach.

J. J. McCABE,
SUCCESSOR TO
E. P. BULLARD'S N. Y. Mach'y Warerooms.
14 Dey St., NEW YORK.

MACHINERY BARGAINS.

10 in. Post Drill.
10 " " Auto. Feed to Table for Butt Drilling.
1, 2 and 3 Spindle Sensitive with and without Power Feed.
2, 3 and 4 Spindle Gang Drills.
20 24, 26, 28, 30 and 44 in. "
30 in. Swing Post Drill.
5 ft. Arm Radial Drill.
12 in. Stroke, 16 in. x 16 in. Crank Planer.
16 in. x 4 ft. Planer.
24 " 4, 5 and 6 ft. Planer.
28 " 5 and 8 " "
30 " 5, 8 and 10 " "
60 " 20 " "
72 " 25 " "
9, 12, 16 24 and 26 in. Stroke Shaper.
10 in. Stroke Slotter.
Hyd. Rivetting Machine.
" Crane, Both Al.
Punch and Shear.
Plate Planer.
11 in. x 5 ft. Eng. Lathe.
14 " 6 " " "
15 " 6 and 8 ft. Eng. Lathe.
16 " 5 6, 7 and 10 ft. Eng. "
18 " 6 7 and 8 " " "
20 " 5, 6, 7, 8 and 10 ft. " "
21 " 10 and 13½ ft. " "
24 " 13 " " "
25 " 16 and 24 " " "
26 " 10½ " " "
32 " 16 " " "
35 " 13 " " "
52 " 35 " " "
57 in. Double Head Driving Wheel Lathe.
Bement Car Axle Lathe.
1¼ & 2 in. Bolt Cutter Schenk's.
7 Spd'l Nut Tapper, Dunel.
2 Spd'l Profiler, No. 1 P. & W.
No. 1, 2 and 2½ Screw Machs. P. & W.
No. 1 Lincoln Pattern Miller.
Hand Millers, Screw Slotters, Mill and Cutter Grinders.

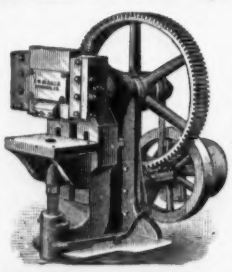
Lot of Miscellaneous Machinery, Engines, etc. Send for Latest List.

GEO. PLACE MACHINE CO.,
Offices: 145 BROADWAY and 86 LIBERTY ST.
Warehouse: 511 and 513 WEST 13th STREET,
NEW YORK.

The "Eclipse" Drill, Tool and Graver Sharpener.

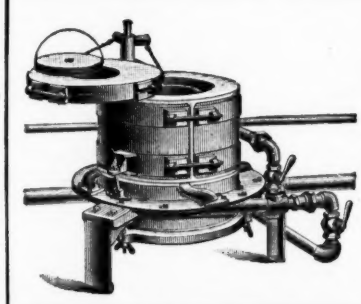
The only practical device for the re-sharpening of drills or any other tools requiring a flat surface and fine edge. It can be adjusted to any angle, and by aid of the degree or index marks the drill or tool can be set to the desired angle almost instantly.
Price, Size A $1 75, sent post paid on receipt of price.
EZRA F. BOWMAN & CO.,
22 E. Chestnut St., Lancaster, Pa.

E. W. BLISS CO.
1 ADAMS ST., BROOKLYN, N. Y.
Chicago Office, 100 W. Washington Street.



PRESSES, DIES, PUNCHES.
DROP HAMMERS, SHEARS AND SPECIAL MACHINERY.
The STILES & PARKER PRESS CO.

TOOLS
FOR
SHEET METAL WORK,
Niagara
PRESSES, DIES, TINNERS' TOOLS, SHEARS,
NIAGARA STAMPING AND TOOL CO.,
BUFFALO, N. Y.



AMERICAN GAS FURNACE CO.,
OIL GAS PLANTS
Gas Blast Furnaces & High Pressure Blowers
For the economical generation and systematic application of HEAT.
CATALOGUES ON APPLICATION.
No. 80 Nassau Street, - - NEW YORK.
English Agency:
Chas. Churchill & Co., Ltd., 21 Cross Street, Finsbury, London, E. C., England.

SECOND-HAND MACHINE TOOLS.

ENGINE LATHES.
13 in. x 5 ft. Phenix.
14 " x 6 " Bogart.
15 " x 6 " Blaisdel.
15 " x 8 " Fitchburg.
16 " x 6 " Perkins.
16 " x 7 " Bement.
16 " x 6 " F. E. Reed.
18 " x 6 " New Haven
18 " x 8 " Pease.
18 " x 8 " Blaisdel.
18 " x 10 " "
20 " x 6 " Bullard.
29 " x 12 " Fifield.
30 " x 12 " Blaisdel.
37 " x 14 " Old Style.

PLANERS.
22 in. x 22 in. x 4 ft. L. W. Pond.
24 " x 24 " x 6 " Whitcomb.
24 in. x 24 in. x 10 ft. Pease Planer Co.
28 in. x 28 in. x 7 ft. New Haven.

SHAPERS.
10 in. Juengst Crank.
10 " Wood and Light Traverse Head.
15 in. Juengst Crank.
18 " Putnam Traverse Head.

HAND LATHES.
4 10 in. x 41 in. Garvin.
1 12 " x 4 ft Garvin
1 11 " x 4 " Standard.
1 12 " x 5 " Back Geared.
2 20 " x 6 " Back Geared.

MIS ELLANEOUS.
Garvin Profiler, one Spindle.
6 in. Bement Slotter.
42 " Gould & E. Auto. Gear Cutter.
16 in. x 5 ft. Gage Square Arbor Fox Lathes.
5 in. Cutting off Machine.
No. 2 Springfield Tool Grinder.
" 4 " " "
30 in. Squaring Shear.
No. 2 Pratt & Whitney Die Sinker
No. 3 Garvin Cutter and Tool Grinder
No. 2 Garvin Cutter and Drill Grinder.
No. 1 Slate Marking Machine.
No. 2 Garvin Automatic Tapper.
Garvin Die Slotter.
Garvin Wire Spring Coiler.

Also, a large number of other machines. Write for complete list and detailed description.

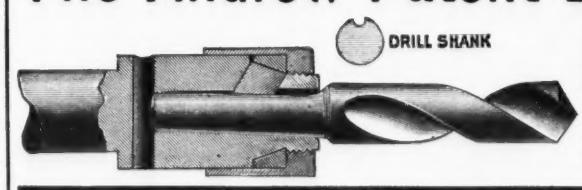
THE GARVIN MACHINE CO.,
LAIGHT & CANAL STS., NEW YORK.
Also 51 North 7th St., Philadelphia, Pa.

ELECTRIC TELEPHONE
Sold outright, no rent, no royalty. Adapted to City, Village or Country. Needed in every home, shop, store and office. Greatest convenience and best seller on earth.
Agents make from $5 to $50 per day.
One in a residence means a sale to all the neighbors. Fine instruments, no toys, works anywhere, any distance. Complete, ready for use when shipped. Can be put up by any one, never out of order, no repairing, lasts a life time. Warranted. A money maker. Write
W. P. Harrison & Co., Clerk 10, Columbus, O.

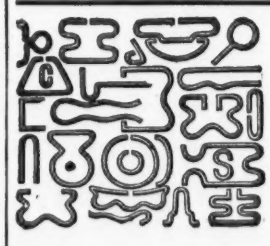
NO MACHINIST
will do without it, if he ever saw or used one of the
"COLUMBIA" CALIPERS.
WHY NOT GET ONE YOURSELF?
For Catalogue and Prices address,
E. C. SMITH, Columbia, Pa.

IF YOU WANT ANYTHING IN THE LINE OF
DROP PRESSES, DROP HAMMERS, STAMPS OR AUTOMATIC DROP LIFTERS.
SEND FOR CATALOGUE TO
Miner & Peck Mfg. Co.
NEW HAVEN, CONN.
LARGEST LINE IN THE MARKET

The Andrew Patent Drill Chuck.

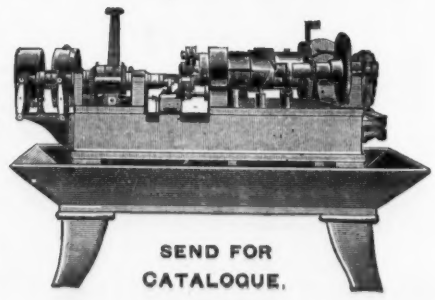


The original (not copied) device to prevent twisting off Tangs. No extra cost for ANDREW'S reverse incline groove in the shanks. Chucks made direct on new or old spindles. Holds heavy taper-shank tools from dropping out. Best Practical Chuck in the World. Endorsed by all prominent Twist Drill Makers and Mechanical Experts. Send for catalogue.
M. L. ANDREW & CO.,
CINCINNATI, OHIO.



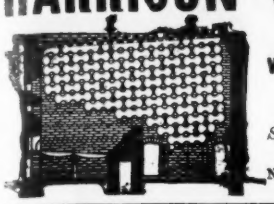
BLAKE & JOHNSON,
WATERBURY, CONN.
Builders of WIRE FORMING MACHINES
With F. B. Manville's Patent Sliding Former,
For making articles from the coil, of either round, half-round, flat, or square wire, similar in shape to those shown in the cut herewith. Also similar articles made to order.
Send samples of articles required, and mention quantity wanted, that we may quote prices for either machine or the goods, whichever may be desired.
Bicycle and Labor Saving Machinery a Specialty.

STEEL BALLS
For all Anti-Friction Purposes.
WE ALSO MANUFACTURE
AUTOMATIC SCREW MACHINES
AND
SCREW MACHINE PRODUCT
OF EVERY DESCRIPTION.
Cleveland Machine Screw Co.,
CLEVELAND OHIO.



SEND FOR CATALOGUE.

HARRISON SAFETY BOILER WORKS.

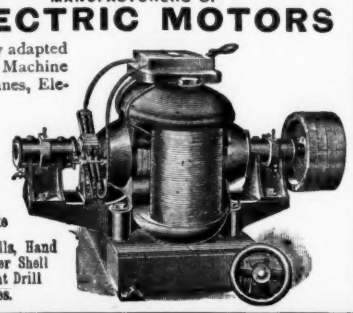


ENGINEERS AND CONTRACTORS FOR
Complete Steam Generating Plants, including
WHARTON-HARRISON SAFETY BOILERS, COCHRANE FEED-WATER HEATERS, HEATERS AND PURIFIERS, SPECIAL HEATERS, COCHRANE SEPARATORS, CAST IRON TANKS, &C.
Specifications and estimates furnished on receipt of details of requirements.
Works and Main Office: GERMANTOWN JUNC., PHILA., PA.
NEW YORK, N. Y.: 616 Havemeyer Building. ATLANTA, GA.: Chas. H. Wilcox,
DALLAS, TEX.: Hunter & Booso.

THOS. H. DALLETT & CO.,

YORK ST. & SEDGLEY AVE., PHILADELPHIA.
MANUFACTURERS OF
ELECTRIC MOTORS

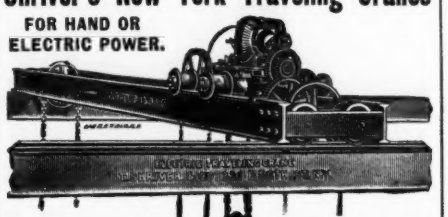
Specially adapted for driving Machine Tools, Cranes, Elevators, Pumps, Presses, and other Machinery.



We also make
Portable Drills, Hand Drills, Boiler Shell Drills, Light Drill Presses.

Shriver's New York Traveling Cranes

FOR HAND OR ELECTRIC POWER.



T. Shriver & Co. 333 East 56th St., NEW YORK.
MANUFACTURERS OF
TRAVELING CRANES of 1½, 2, 3, 5 and 10 Tons capacity, to be operated by Hand, or wholly or in part by Electricity.

Norton Emery Wheel Co.

SEND FOR ILLUSTRATED CATALOGUE
Worcester, Mass.

HIGH SPEED POWER

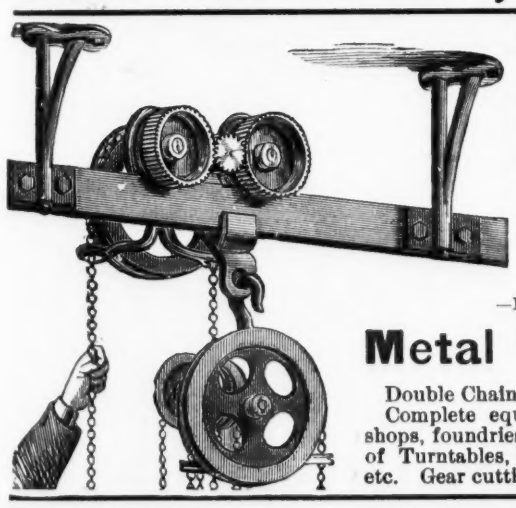
TRAVELING CRANES.

Driven Either by Rope or Belt, or by Electric Motor.
MANUFACTURED BY
ALFRED BOX & CO.,
Front, Poplar and Canal Sts.,
PHILADELPHIA, PA
Send for Circulars and References.

CRANES TROLLEYS, PORTABLE HOISTS, OVERHEAD TRACK.
SEND FOR CATALOGUE.

MARIS AND BEEKLEY,

2343 & 2345 Callowhill St.,
PHILADELPHIA, PA.



EDWIN HARRINGTON, SON & CO.

ESTABLISHED 1867.
(Incorporated.)
1515 Pennsylvania Ave.,
PHILADELPHIA, PA.
—MANUFACTURERS OF—
Metal Working Tools.

Double Chain Screw Pulley Blocks or Hoists.
Complete equipment of overhead Railways for shops, foundries, warerooms, etc., consisting in part of Turntables, Switches, Plain and Geared Trucks, etc. Gear cutting a specialty.

"PRACTICAL DRAWING."

By J. G. A. MEYER.

The demand for back numbers of the American Machinist, containing this valuable series of articles, has been so great, that, orders can hereafter be filled by the set only.

The set of 92 papers will be sent by mail to any address in the U.S., Canada or Mexico for $5.00, postpaid, and to any foreign country for $7.00.

Order now before our stock of papers is exhausted.

American Machinist,
203 BROADWAY,
NEW YORK.

Dixon's Silica Graphite Paint

Will preserve a roof for TEN to FIFTEEN YEARS—perhaps longer, without repainting.
Unequaled for SMOKE STACKS, BOILER FRONTS, Etc.

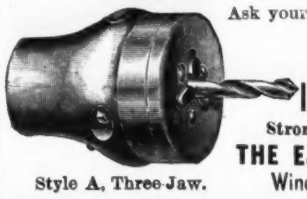
Send for circulars on Paints and Painting.

JOS. DIXON CRUCIBLE CO., Jersey City, N. J.

COILS and BENDS of IRON, BRASS, and COPPER PIPE of every description.

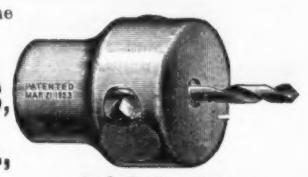
The National Pipe Bending Co.
52 River St., New Haven, Conn.

Ask your nearest Dealer, or send to the Manufacturers for



THE LATEST IMPROVED DRILL CHUCKS,

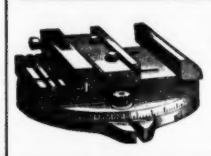
Strong, Accurate, Durable, Cheap.
THE E. HORTON & SON CO.,
Windsor Locks, Conn., U. S. A.



Style A, Three-Jaw. Style B, Two-Jaw.
Or CHAS. CHURCHILL & CO., Ltd., 21 Cross St., Finsbury, London, Eng. **Awards at the World's Fair.**

"CUSHMAN" CHUCKS.

For Lathes, Drills, Chucking and Screw Machines, and for Special work. . . . . .
SEND FOR CATALOGUE.
THE CUSHMAN CHUCK CO., HARTFORD, CONN.



Jordan Planer Chucks.

For Price and Description, address
C. W. JORDAN
4 Wayne St.,
WORCESTER, MASS.

CHUCKS The "National."

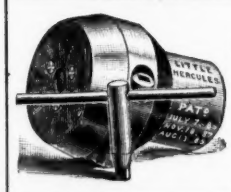
INDEPENDENT, UNIVERSAL, or COMBINATION.
Est'd 1882. Strongest. Easiest to change. Best finish. **Reversible Jaws** (patented) giving 5 changes including every possible position. ILLUSTRATED CATALOGUE sent. Liberal discounts. Prompt shipment. **W. WHITLOCK,** 39 Cortlandt St., N. Y.—Works, Hoboken, N.J.

WE LEAD, OTHERS FOLLOW.

Sweetland Combination Chuck.
Reversible Jaws. Accurate, Standard Independent, Solid Shell, Solid Reversible Jaws, Strong and True.
SEND FOR CATALOGUE.
The HOGGSON & PETTIS MFG. CO., - New Haven, Conn.

DRILL CHUCKS.

LOW in Price—HIGH in Efficiency.
WRITE TO
TRUMP BROS. MACHINE CO., MFRS.,
WILMINGTON, DELAWARE.
FOR SALE BY
CHAS. CHURCHILL & CO., Ltd., LONDON, ENGLAND.



THE
Oneida Mfg. Chuck Co.

ONEIDA, N.Y., U.S.A.
Manufacturers of The Monarch Lathe Chuck and Little Hercules Drill Chuck. Write for catalogue direct, or to
CHAS. CHURCHILL & CO., Ltd.,
21 Cross Street,
Finsbury, London, ENGLAND.

Cranes

CUPOLAS, LADLES, TRUCKS,
Whiting Foundry Equipment Co.,
225 DEARBORN ST., CHICAGO. | HARVEY, ILL.
NEW YORK OFFICE, 182 FRONT ST.

PRATT INSTITUTE,

BROOKLYN, N. Y.
Department of Science and Technology.

The two years' day course in machine work, gives thorough preparation for practical work. Tuition, $30.00 per term of six months. Evening classes meet on Monday, Wednesday and Friday, for course of six months, beginning September 24. Tuition, $15.00. Tools and materials furnished without extra charge. For further particulars, address F. B. Pratt, Sec'y.

PEQUOT DRILL CHUCK.

A new Drill Chuck having a more powerful grip than any chuck ever offered. This seems a broad claim, but we prove it to mechanics who will examine. Ask at your dealers or write us for particulars.
THE D. E. WHITON MACHINE CO.,
5 Oak Street, New London, Conn, U. S. A.,
OR, SELIC, SONNENTHAL & CO.,
85 Queen Victoria St., London, E. C., England.

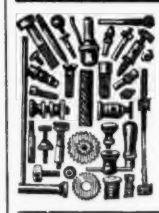
NEW SKINNER CHUCK.

Catalogue, just published, will be sent to any interested parties on receipt of request for same.
(48 pages chuck full.) **THE SKINNER CHUCK CO.,**
NEW BRITAIN, CONN., U. S. A.

Write **The Pratt Chuck Co.,** Clayville, N. Y., U. S. A., for free illustrated catalogue of

POSITIVE DRIVING DRILL CHUCKS.

Will drive either straight or Taper Snank Drills, Reamers, Rose Bits, etc., of any size, without a possibility of their slipping.
FOREIGN AGENCIES:
Ph. Roux et Cie., 54 Boulevard du Temple, Paris, France; E. Sonnenthal, Jr., Neue Promenade No, 5, Berlin, Germany; Selig, Sonnenthal & Co., 85 Queen Victoria St., London, E. C., England.



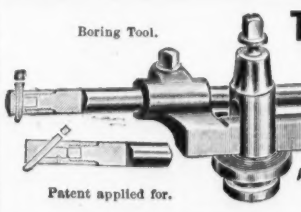
Special Screws and Studs in Brass or Steel.

Gear Cutting, Sheet Metal Stamping, Automatic Machinery built to order. Send sample or drawing for estimate.
SITTMANN & PITT,
353 ADAMS ST., BROOKLYN, N. Y.

Albro Worm and Worm Gear

Consumes less power and gives better results than any other System. Information cheerfully furnished.
The Albro-Clem Elevator Co.,
411 & 413 Cherry St.,
Philadelphia, Pa.

Boring Tool.



Patent applied for.

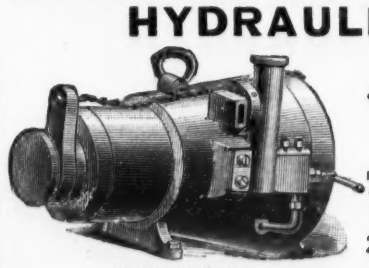
THIS WILL GIVE YOU AN IDEA

of how these tools gain in favor after being once tried.
WAYNESBORO, PA, May 27.
From FRICK CO.
Send us one each, Nos. 1, 2, 3 and 5 for trial. To be returned if not satisfactory.
July 11.
Send us one Dozen each, Nos 1, 2, 3 and 5.
For circulars, prices, etc., send to
ARMSTRONG BROS. TOOL CO., 76 Edgewood Ave., Chicago,
Or to your nearest first-class dealer.
CHAS. CHURCHILL & CO., Ltd., London, Eng., Agents.

Lathe and Planer Tool.

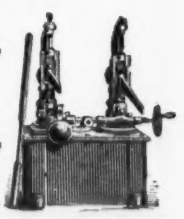
Patent, Feb. 28, 1893.

HYDRAULIC MACHINERY.

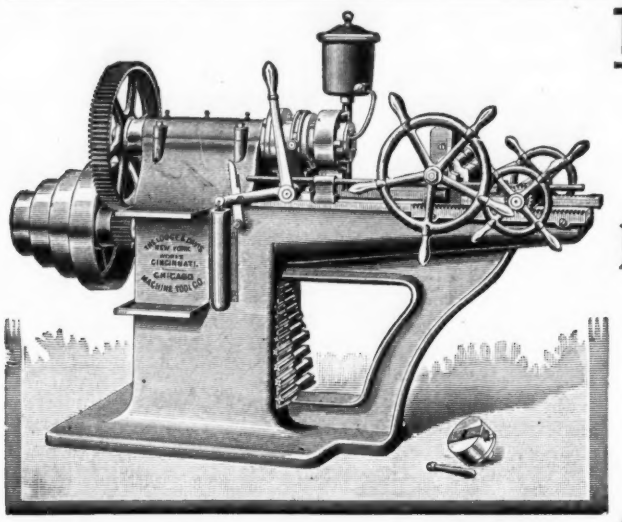


Horizontal Jack.

PRESSES, PUMPS, PUNCHES,
JACKS, VALVES, FITTINGS,
PACKINGS, ACCUMULATORS.
SEND FOR CATALOGUE D.
The W. & S. Hydraulic Machinery Works,
WATSON & STILLMAN, Proprietors,
204, 206, 208 & 210 East 43d St.,
NEW YORK.



2-Plunger Hand Pumps



AUTOMATIC BOLT CUTTERS.

The LODGE & DAVIS MACHINE TOOL CO.

DESIGNERS AND BUILDERS OF

MACHINE SHOP EQUIPMENTS

Including Standard Engine Lathes, Planers, Shapers, Drill Presses, Milling Machines, Screw Machines, Turret Lathes, Pulley Lathes, Etc., Etc.

WORKS: CINCINNATI, OHIO, U. S. A.

NEW YORK. CHICAGO. ST. LOUIS. PITTSBURGH.

Lathes

OUR PAT. RADIAL DRILLS ARE BEST.

Good tools produce good work, we use only the finest machinery and employ the most skilled Mechanics, hence, are in position to offer the best Mechanisms to be obtained at a moderate price.

ENGINE LATHES.

22" and 24" furnished in lengths of 8, 10, 12, 14, and 16 feet Bed.

With all modern Improvements.

Address,
Dietz, Schumacher & Co.,
Cincinnati, O., U. S. A.

ENGINE-LATHE IMPROVEMENTS.

Independent of Increased Diameters of Cones and Bearings.

DIAMETERS AND LENGTHS may be made without the use of rules or calipers

DIAMETERS REPEATED ABSOLUTELY either in turning or chasing, also without calipers.

WITHDRAWING THE TOOL reverses the carriage when screw-cutting.

CHANGE GEARS are all steel and mounted on one shaft.

CUTS THE ENTIRE INDEX of screws without removing a single gear and cuts spirals a duplicate of screw-cutting index.

MOST SUBSTANTIAL in design. Price, just where you can afford it.

GUARANTEED equal to any tool made, in accuracy, solidity and workmanship.

SIZES, 18", 22", 26" and 30" for quick delivery.

Write for "25 Points of Excellence," important as above.

THE LODGE & SHIPLEY M. T. CO., CINCINNATI, O., U. S. A.

DROP FORGINGS

WYMAN AND GORDON
WORCESTER, MASS.

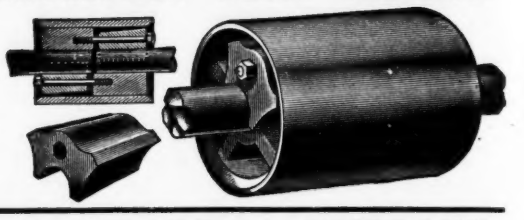
STUART'S PATENT COMPRESSION WEDGE COUPLING.

NO KEYS. KEY SEATING. SLIPPING.

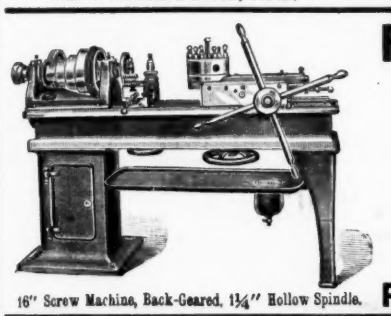
CHEAPEST in MARKET, also the SIMPLEST and BEST.

SENT ON TRIAL.

Can be attached or removed in a few seconds without injury to shaft or coupling. Send for discount and illustrated Price List of 40 sizes.



R. J. STUART'S FOUNDRY AND MACHINE WORKS,
NEW HAMBURGH, N. Y.



16" Screw Machine, Back-Geared, 1¼" Hollow Spindle.

FLATHER & COMPANY,

NASHUA, N. H., U. S. A.

LATHES,

SCREW MACHINES,

PLANERS AND SHAPERS.

Do you make Shrink or Force Fits?

We have an Inside Micrometer Caliper that is just the tool for this purpose. Its price is only $1.75.

We have another (price $6.00) that will actually measure a hole or length in inches and fractions thereof from 2⅜" to 13" by thousandths.

WRITE FOR CIRCULARS.

J. T. SLOCOMB & CO., Providence, R. I.

MACHINERY

For Reducing and Pointing Wire.

ESPECIALLY ADAPTED TO POINTING WIRE RODS AND WIRE FOR DRAWING.

For Machines or Information address the Manufacturer,

S. W. GOODYEAR, Waterbury, Conn.

EVERY MACHINIST SHOULD HAVE A COPY OF

OUR CATALOGUE.

It is a 704 page cloth bound book. A copy will be sent, express paid, to any one sending $1.00, and the money paid for book will be refunded with first order amounting to $10.00 or over.

MONTGOMERY & CO.,

105 FULTON STREET,
NEW YORK CITY.

SOFT CASTINGS,

Made from best grades of Pig Iron for Light Machinery, Electric Work, etc.

THE BURR & HOUSTON CO.,

33 TO 39 FRANKLIN ST., BROOKLYN, N. Y.

MARK YOUR TOOLS WITH A STEEL STAMP.

SEND FOR PRICE LIST NO. 4.

BOSTON GEAR WORKS

35 HARTFORD ST., BOSTON, MASS.

GEARS, ALL KINDS, SMALL OR LARGE.

300 LIST IRON, 600 LIST BRASS.

Catalogue FREE to any Business Firm.

CASTINGS

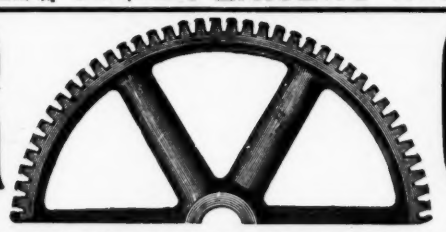
For Machinery of any size, from patterns or drawings. Quality and finish unsurpassed. Prices way down.

L. E. HOYT & CO.,

WALTON, DEL. CO., N. Y.

New York Agent, CLEVELAND FOOTE, 47 Broadway.

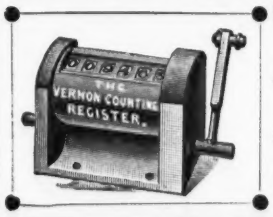
GEARS CUTTING



LELAND, FAULCONER & NORTON CO. Detroit, Mich.

THE VERNON

Revolution Counters, Car Fare Registers, &c.



Positive Motion.
Steel Gearing.
Brass Wheels.
Absolutely Accurate.

S. M. BALZER,
Manufacturer of Counting and Measuring Machines.
129 Worth Street
NEW YORK.

VOLNEY W. MASON & CO.,

MANUFACTURERS OF

NEW PAT. WHIP HOIST,

Pat. Friction Pulleys.

"Two Medals Awarded at Chicago Exhibition."

PROVIDENCE, R. I., U. S. A.

THE PERFECT DRAWING TABLE

With Adjustable Parallel Ruler,
More Reliable Than The Old T-Square.

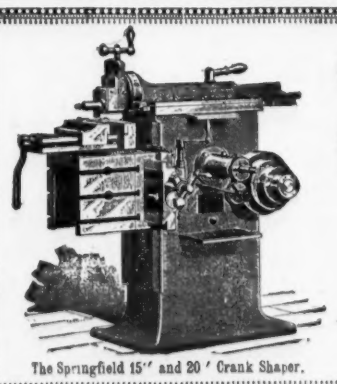
30x42	36x48	36x60
$30.	$35.	$40.

Henry J. Hughes,
360 45TH STREET,
BROOKLYN, N. Y.

NEW BENCH DRILL.

Flat Belt, Rack and Pinion Feed.
(Write for Circular.)

D'AMOUR & LITTLEDALE, 204 E. 43d St., New York.



The Springfield 15" and 20' Crank Shaper.

600 IN USE!

Second Largest Builders in the U. S. of

15" and 20" Crank Shapers

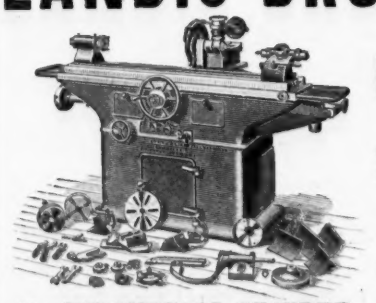
Stroke adjustable while running.
Stroke always positive. The vise is swiveled, and centres furnished.
Improved Box table, and removable.
Heavily Geared.—**Strong, Heavy and Rapid.** Write us.

THE SPRINGFIELD MACHINE TOOL CO.,
SPRINGFIELD, OHIO.

LANDIS BROS., WAYNESBORO, PA.,

MANUFACTURERS OF

Universal and Plain Grinding Machines.



No. 3 UNIVERSAL GRINDER.

A trial of our machine will convince the unprejudiced of its many merits and points of superiority. Fully guaranteed machines in stock.

SEND FOR CATALOGUE.

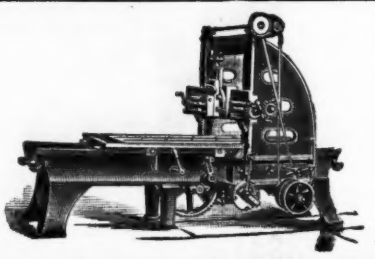
England: Chas. Churchill & Co., 21 Cross St., Finsbury, London, E. C.

France and Belgium: Ad'Janssens, 16 Place de la Republique, Paris.

MORSE TWIST DRILL AND MACHINE COMPANY,
Manufacturers of Morse Patent Straight-Lip Increase Twist Drills. New Bedford, MASS.

Solid and Shell Reamers, Beach's Patent Self-Centering Chuck, Bit Stock Drills.
DRILL GRINDING MACHINES, MILLING CUTTERS AND SPECIAL TOOLS TO ORDER.

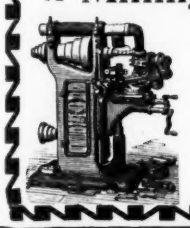
F. E. REED CO.,
Worcester, Mass.,
MANUFACTURE
ENGINE LATHES
HAND LATHES, FOOT LATHES AND MILLING MACHINES.
Manning, Maxwell & Moore,
Selling Agents, 111 Liberty St., New York.
60 South Canal St., Chicago.



New Haven Manf'g Co.,
NEW HAVEN, CONN.
IRON-WORKING MACHINERY

W. C. YOUNG MFG. CO., WORCESTER MASS.
Foot Lathes, Engine Lathes,
SHEARS AND PUNCHES.

A Milling Machine or . . . . a Cutter and Tool Grinder.



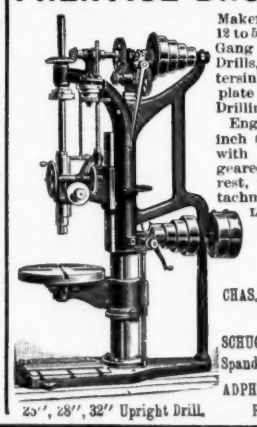
If you need either, and where is the shop that doesn't? write
The Cincinnati Milling Machine Co.,
Cincinnati, Ohio.

NEW LINE OF ENGINE LATHES.
DRAPER MACHINE TOOL CO.
SUCCESSOR TO LATHE & MORSE TOOL CO.
WORCESTER, MASS.

ARMSTRONG'S PIPE THREADING —AND— Cutting-off Machines

Both Hand and Power. Sizes 1 to 6 inches. Water, Gas, and Steam Fitters' Tools, Hinged Pipe Vises, Pipe Cutters. *Stocks and Dies universally acknowledged to be* THE BEST. *Send for catalog.*
Armstrong Mfg. Co., Bridgeport, Conn.

PRENTICE BROS., *Worcester, Mass.*

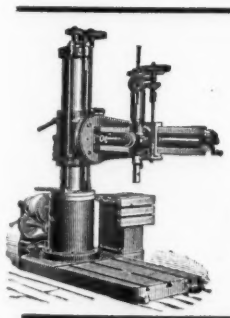


Makers of Vertical Drill Presses 12 to 50-inch swing, Radial Drills, Gang Drills, Boiler Makers Drills, Radial Drilling and Countersinking Machines, for ship plate and bridge work, Special Drilling Machinery.
Engine Lathes from 11 to 21-inch swing, any length of bed with single or double back-geared heads and any style of rest, with or without taper attachment. SEND FOR CATALOGUE.

25", 28", 32" Upright Drill.

Foreign Agents:
CHAS. CHURCHILL & CO., L't'd, London, Eng.;
SCHUCHARDT & SCHUTTE, 59-61 Spandauerstrasse, Berlin, Germany;
ADPHE JANSSENS, 16 Place de la Republique, Paris, France.

BEVEL GEARS,
Cut Theoretically Correct.
For particulars and estimates apply to
HUGO BILGRAM,
MACHINIST,
Successor to
BREHMER BROS.,
440 N. 12th St., Philadelphia, Pa.



Combination Drilling, Boring and Turning . . Machines

THESE TOOLS ARE JUST OUT!

A perfect combination of three distinct tools. Cost very reasonable. Will pay in every machine shop. Apply to

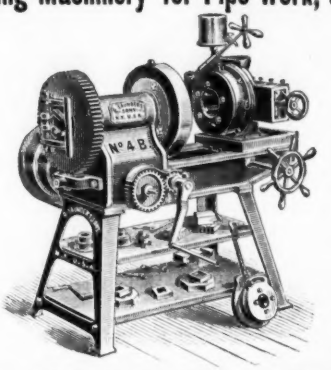
BICKFORD DRILL AND TOOL CO.
3 Pike Street, - - - Cincinnati, Ohio.

Stover Power Hack Saw and Friction Drills.

Saws made in two sizes Nos. 1 and 2. Cut 4½ to 8 inches. Send for circulars to
STOVER NOVELTY WORKS
Mfgrs. of Wood and Iron-Working Machinery. Special Machinery to order
23 River St., FREEPORT, ILL., U. S. A.
C. W. BURTON, London, Eng.

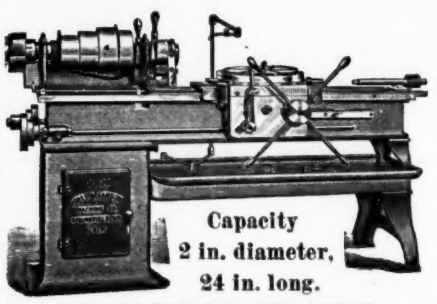
MACHINISTS' SCALES,
PATENT END GRADUATION.
We Invite Comparison for Accuracy with all others.
EVERY SCALE GUARANTEED. SEND FOR LIST.
COFFIN & LEICHTON, SYRACUSE, N. Y.

D. SAUNDERS' SONS,
MANUFACTURERS OF
PIPE CUTTING AND THREADING MACHINES,
Steam and Gasfitters' Hand Tools,
Tapping Machinery for Pipe Work, etc.



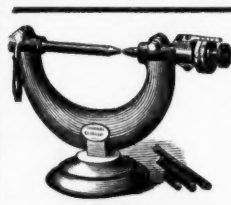
The No. 4 B Machine for Cutting and Threading Pipe ⅛ in. to 4 in., by HAND or POWER.
SEND FOR CATALOGUE TO
21 Atherton St., YONKERS, N. Y.

JONES & LAMSON MACHINE CO.,
SPRINGFIELD, VERMONT.
SOLE BUILDERS OF THE
FLAT TURRET LATHE.
ALSO BUILDERS OF OTHER
TURRET MACHINERY.
PUBLISHERS OF
"RAPID LATHE WORK,"
BY NEW METHOD.
(Hartness System.)



Capacity 2 in. diameter, 24 in. long.
2 BY 24 FLAT TURRET LATHE.

SEND FOR CATALOG.



SWEET'S Measuring Machine.
The only micrometer that will not lose its accuracy by wear.
Satisfaction Guaranteed,
SYRACUSE TWIST DRILL CO.,
Syracuse, N. Y.

American Standard Gauge & Tool Works,
WILMINGTON, DEL.

Adjustable Blade Reamers,
⅛ in. to 2½ in.
Send for New Pamphlet.
JAMES A. TAYLOR & CO.

P. BLAISDELL & CO.,
Manufacturers of
Machinists' Tools,
WORCESTER, MASS.

CUTTING-OFF MACHINES.
HURLBUT-ROGERS MACHINE CO.,
SO. SUDBURY, MASS.

SEND FOR CATALOGUE.
WORCESTER MACHINE SCREW CO.

Manufacturers of Set, Cap & Machine Screws, Studs, etc.

INSTRUCTION BY MAIL
IN ARCHITECTURAL DRAWING,
ARCHITECTURE,
PLUMBING, HEATING AND VENTILATION,
BRIDGE ENGINEERING,
RAILROAD ENGINEERING,
SURVEYING AND MAPPING,
ELECTRICAL ENGINEERING,
MECHANICAL DRAWING,
MINING,
ENGLISH BRANCHES, AND
MECHANICS.

Diplomas awarded. To begin students need only know how to read and write. Send for FREE Circular of Information, stating the subject you think of studying to

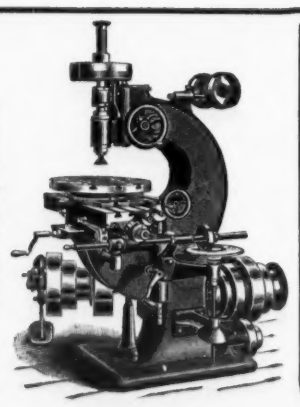
The Correspondence School of Mechanics and Industrial Sciences.
SCRANTON, PA.

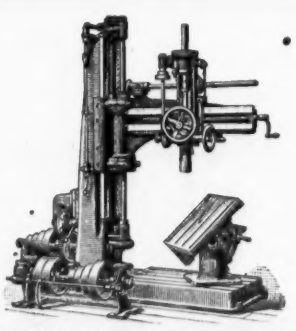
4000 STUDENTS

W. D. FORBES & CO.,
1300 HUDSON STREET,
HOBOKEN, N. J.

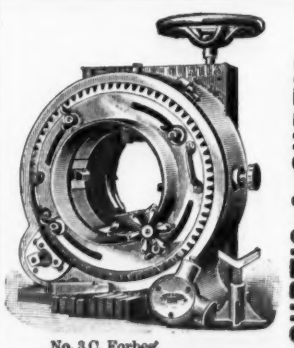
FINE MACHINE WORK OF ALL KINDS WITHIN THE RANGE OF OUR TOOLS IS DESIRED.

THE BECKER MILLER No. 4
MANUFACTURED BY
JOHN BECKER MANUFACTURING CO.,
FITCHBURG, MASS.





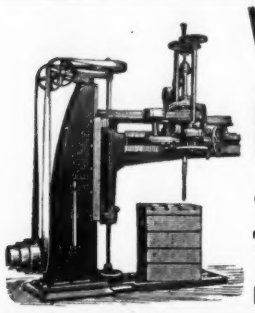
THE AURORA TOOL WORKS, Aurora, Ind.
Builders of Upright and Radial Drills.



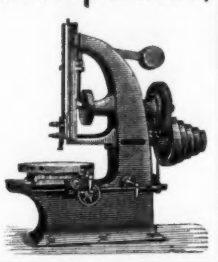
No. 3 C. Forbes' Patent Die Stock. Range 2¼ to 6 inches R. H.

CURTIS & CURTIS,
66 CARDEN ST., BRIDGEPORT, CONN.
Pipe Cutting and Threading Machinery,
FOR HAND OR POWER,
RATCHET DRILLS, RATCHET DIE STOCKS AND MALLEABLE IRON PIPE VISES.

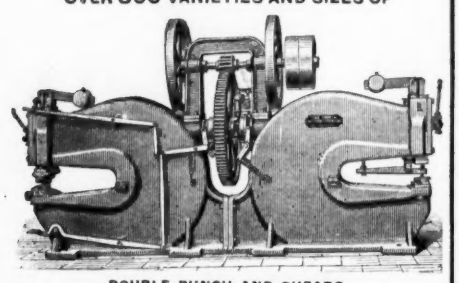
BARNES' UPRIGHT DRILLS
Complete line, ranging from our New Friction Disk Drill, for light work, to 42-inch Back Geared Self Feed Drill.
Send for Catalogue and Prices.
W. F. & JOHN BARNES CO.,
1995 Ruby St., Rockford, Ill.
ENGLISH AGENTS,
CHAS. CHURCHILL & CO., LTD.,
21 CROSS ST., FINSBURY, LONDON, E.C., ENG.



WM. SELLERS & CO., Incorporated,
PHILADELPHIA, PA.
MANUFACTURERS OF
MACHINE TOOLS,
TRAVELING CRANES AND SWING CRANES,
Operated by Electricity, Shafts or Independent Engines.
Turn Tables, Testing Machines, Shafting, Pulleys, Hangers, Couplings, Etc.
INJECTORS FOR ALL CLASSES OF BOILERS.



THE LONG & ALLSTATTER CO.,
HAMILTON, OHIO, U. S. A.
OVER 300 VARIETIES AND SIZES OF



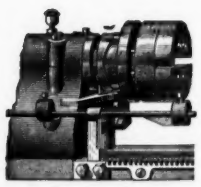
DOUBLE PUNCH AND SHEARS.

PUNCHES AND SHEARS WELDING MACHINES AND DROP HAMMERS.

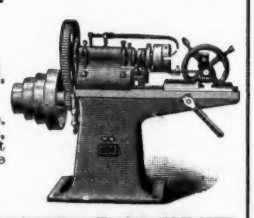
New Speed Indicator
No. 106.
Working parts enclosed like a watch, and as well made. Graduations show every revolution, reading either right or left. Nickel plated.
Many improved features make this the best Indicator on the market at anywhere near the price.
PRICE: PLAIN, $1.50.
" WITH SPLIT CAP, $1.75.
Catalogue of Fine Tools free.
L. S. STARRETT,
ATHOL, MASS., U. S. A.
London Agents: Chas. Churchill & Co., Ltd., 21 Cross St., Finsbury, E. C.

IF YOU HAVE ANY SMALL ARTICLES in Brass or Iron that you want manufactured in quantities, write to THE JONES BROS. ELECTRIC Co., 28-30-32 West Court St., Cincinnati, O.

DETRICK & HARVEY MACHINE CO.,
BALTIMORE, MD.
MANUFACTURERS OF THE
ADAMS
Automatic Bolt-Threading and Nut-Tapping Machine.
Made in all Sizes to Cut from 1-4" to 6".



The simplest and most durable machine in existence. The threading head is made entirely of steel. No links, levers, springs, caps, cases, blocks or die rings in or about the head. Separate Heads and Dies Furnished. Write for descriptive circular and price list.
Manufacturers of The Open Side Iron Planer.



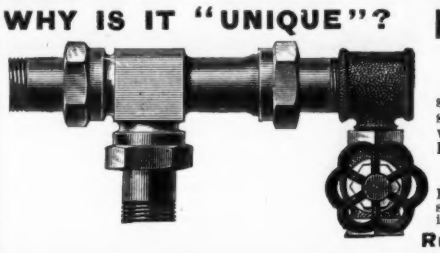
CATCH ON NOW.
You'll never get another chance.
To any one sending us TEN CENTS (stamps or silver), previous to October 1st, we will mail one of our best two inch STEEL RULES with ends HARDENED, Only one rule to the same address.
STANDARD TOOL CO.,
ATHOL, MASS., U. S. A.
MANUFACTURERS OF
MECHANICS FINE TOOLS.

CHAS. A. STRELINGER & CO.,
Tools, Supplies and Machinery
DETROIT, MICH.

THE PERKINS DRAW STROKE TRIMMER,

An Indispensable Tool for all Bench Woodworkers. Latest and Best Design. Infringers Prosecuted. Trial, not orders, solicited.
PERKINS & CO.,
Grand Rapids, Mich.
STOCKS, NEAVE & CO.,
Manchester, England.

WHY IS IT "UNIQUE"?



BECAUSE IT COMBINES SO MANY GOOD POINTS.
It requires no change for varying pressures of steam, can be placed in any position, is simple in construction, conveniently come at for cleaning, and all valves or other fittings required are such as can be had of any dealer.
Do you want to know more about Rue's "Unique" Single Tube Injector?
If so, send for Catalogue describing this and many other styles, and containing also a great deal of information about injectors of use to every engineer or mechanic.
Rue Mfg. Co., 118 N. 9th St., Phila., Pa.

AUTO MATIC
PENBERTHY
INJECTOR
PENBERTHY INJECTOR CO. MFRS, DETROIT, MICH.

UNIVERSAL TRIMMER.
Thousands in Use.
Adopted exclusively by Leading Manufacturers. All Manner of Joining, Trimming and Angling done by a stroke of Lever,
PERFECT WORK. SATISFACTION.
American Machinery Co.
Detroit, Mich., U. S. A.
Cable Address, "TRIMMER."

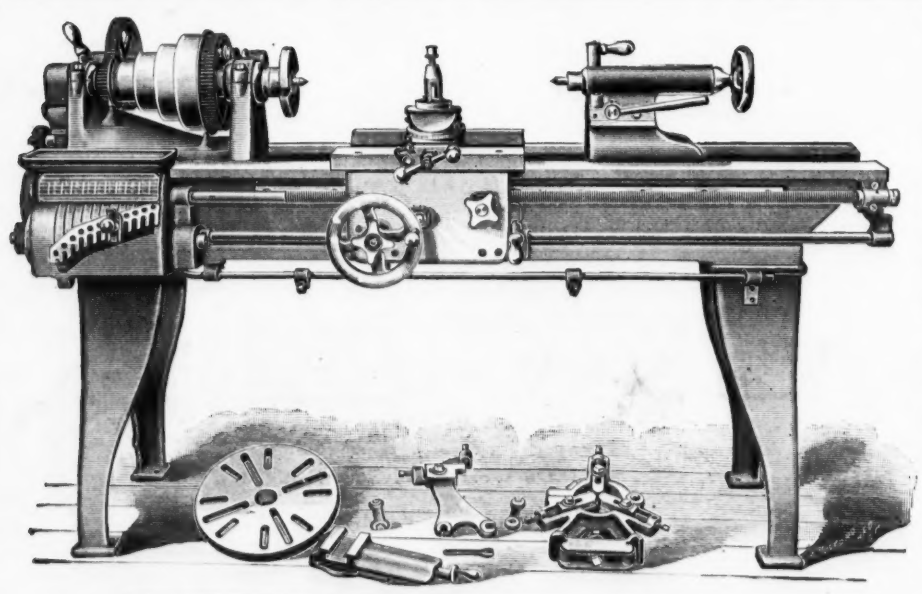
Branch, No. 11 Old Hall St., Liverpool, Eng.

MARKING MACHINE,
For rolling trade-marks on flat or round Iron or Steel surfaces.
Used by Cutlery Pistol, Twist Drill, Wrench, and many other makers.
200 in use.
Read up.
Catalogue "B" free.
DWIGHT SLATE MACHINE CO.,
HARTFORD, CONN.

BACK VOLUMES OF THE AMERICAN MACHINIST
For any of the fourteen years, 1880 to 1893, inclusive, may still be obtained, but must be ordered soon, as our stock is nearly exhausted. Price, unbound, $3.00 per volume postpaid. Bound in cloth, $4.00 per volume (purchaser paying freight or express charges). No separate back numbers prior to 1893 are now carried in stock. Only complete volumes furnished prior to 1893.
AMERICAN MACHINIST, 203 Broadway, New York.

J. A. FAY & CO.,
Offices, FRONT & JOHN STS., Cincinnati, O., U. S. A.
MAKERS OF
Wood-working Machinery
FOR ANY PURPOSE.
"Grand Prix" Paris.
Highest Awards Chicago.
PRINTED MATTER ON APPLICATION.

ROBERT POOLE & SON CO.
ENGINEERS & MACHINISTS.
TRANSMISSION MACHINERY
MACHINE MOULDED GEARING
SPECIAL FACILITIES FOR THE
HEAVIEST CLASS OF WORK
BALTIMORE, MD.



14 in. x 6 ft. Hendey-Norton Lathe with Improved Automatic Stop.

EUROPEAN AGENTS:
SCHUCHARDT & SCHUTTE, 59 Spandauerstrasse, Berlin.
CHAS. CHURCHILL & CO., L'd 21 Cross Street, Finsbury, London.
EUGEN SOLLER, Basel, Switzerland.

THIS Lathe COMBINES the LATEST and BEST Improvements. Automatic Stop. It is Simple, Durable, Indispensable. It will AUTOMATICALLY STOP the Carriage in EITHER direction. It is equally efficient whether FEEDING or THREAD-CUTTING. Running up to a shoulder, boring to BOTTOM of holes, or INTERNAL THREAD-CUTTING. No danger of spoiling either tool or work. It is a safeguard against accidents, in either direction.

Feeds—It has all feeds in daily use with simple movement of lever.

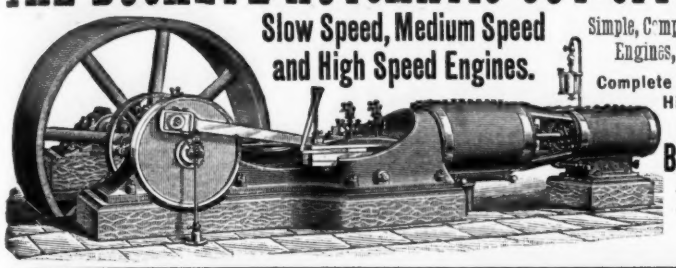
Threads—It has all threads in daily use with simple movement of lever.

Carriage—The Carriage reverses in Apron. No slamming of Countershaft. There is no Comparison between this Lathe and the old style or common lathe. Quick work, rapid changes, satisfactory results. Buy the best. Send for Circular.

THE HENDEY MACHINE CO.,
TORRINGTON, CONN.

THE BUCKEYE AUTOMATIC CUT-OFF ENGINES,

Slow Speed, Medium Speed and High Speed Engines.



Simple, Compound, and Triple Expansion Engines, High Pressure Boilers.

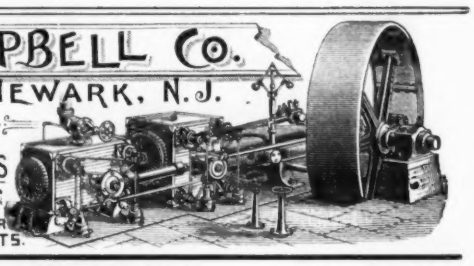
Complete Steam Power Plants of Highest Attainable Efficiency. Address

Buckeye Engine Co.
No. 26 Franklin Ave.,
SALEM, O.

THE WATTS, CAMPBELL CO.

MANUFACTURERS OF IMPROVED CORLISS STEAM ENGINES IN FULL VARIETY.

NEWARK, N. J.



CONTRACTS TAKEN FOR COMPLETE POWER PLANTS.

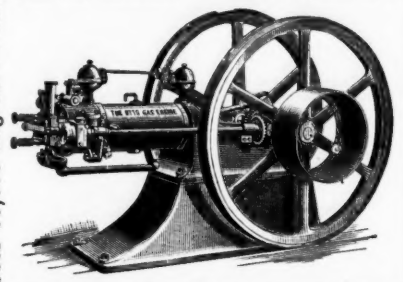
"OTTO" GAS ENGINE WORKS.

SCHLEICHER, SCHUMM & CO.,

33d and Walnut Sts., PHILADELPHIA.

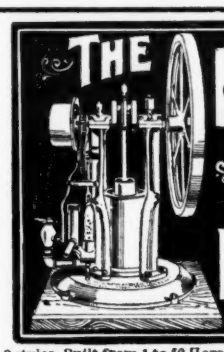
Branch Office, 245 Lake St., CHICAGO.
New York Agency, 18 Vesey St., N. Y.

Over 35,000 Engines in Use



Guaranteed to consume 25 to 75 per cent. less Gas than any other Gas Engine doing the same work.

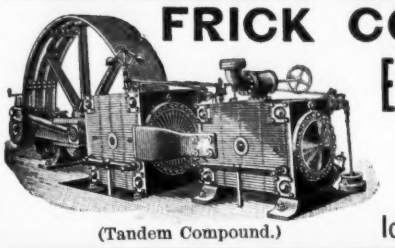
THE BACKUS GAS ENGINE



2 styles, Built from 1 to 50 Horse Power. Send for Circular.

BACKUS WATER MOTOR CO., Newark, N. J.
Also Mfrs. VENTILATING FANS.

FRICK COMPANY, WAYNESBORO, PA.



(Tandem Compound.)

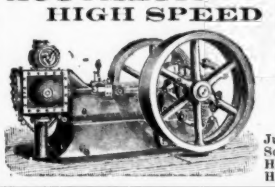
ECLIPSE CORLISS ENGINES,

40 TO 2,000 H. P., ALL STYLES.
Send for Illustrated Catalogue.

ALSO BUILDERS OF
Electric High Speed Engines and Ice-Making and Refrigerating Machinery.

WESTON ENGINES

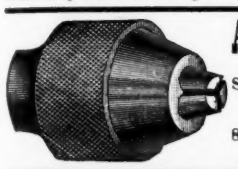
AUTOMATIC HIGH SPEED



HIGH PRESSURE BOILERS AND COMPLETE POWER PLANTS

WESTON ENGINE CO., PAINTED POST, N. Y.

REPRESENTATIVES.
Julian Scholl & Co., 126 Liberty St., N. Y. City.
Scranton Supply & Machinery Co., Scranton, Pa.
Hoffman-Russell Co. 82 Lake St., Chicago, Ill.
H. M. Sciple & Co., 3d & Arch Sts. Phila, Pa.



Almond Drill Chuck.

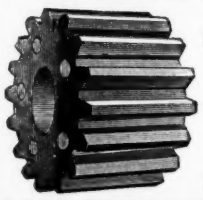
Sold at all Machinists' Supply Stores.

T. R. ALMOND,
83 & 85 Washington St.,
BROOKLYN, N. Y.

STRANGE, BUT TRUE!!

THE NEW PROCESS RAW HIDE GEARS

ASTONISH THE MACHINERY WORLD.

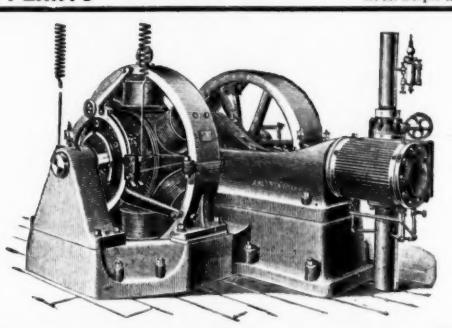


They **Outwear any Metal.**

They require **No Lubricant.**

They are **Noiseless and Clean.**

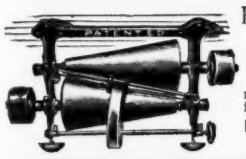
NEW PROCESS RAW HIDE CO.,
PATENTEES AND SOLE MANUFACTURERS,
SYRACUSE, N. Y., U. S. A.



AMES IRON WORKS, OSWEGO, N. Y.

38 Cortlandt Street, New York City.
18 South Canal Street, Chicago, Ill.
50 Oliver Street, Boston, Mass.
518 Arch Street Philadelphia, Pa.

EVANS FRICTION CONE CO.

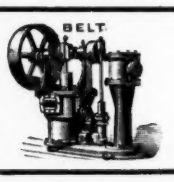


HANGING AND STANDING **CONES,**
MADE IN ALL SIZES.
Thousands in use transmitting from 1 to 50 H. P. For information address,
No. 85 WATER STREET, BOSTON, MASS.

CONOVER'S CONDENSERS

IN STOCK

HANDSOME CATALOGUE ON



THE CONOVER MFG. CO. 39 CORTLANDT ST. N.Y.

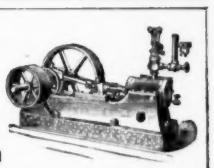
ORR & SEMBOWER,

(INCORPORATED.)

VERTICAL, HORIZONTAL, MARINE

— AND —

HOISTING ENGINES,



VERTICAL AND HORIZONTAL BOILERS.
WRITE FOR CATALOGUE AND PRICES.
116 Liberty St., NEW YORK. Factory at READING, PA. 42 S. Clinton St., CHICAGO.

SEND FOR CATALOGUE . . .

PURDUE UNIVERSITY,

Courses in Mechanical Engineering, Civil Engineering, Electrical Engineering.

Fine Shops and Extensive Laboratories for Advanced Experimental Work.

Address, Secretary PURDUE UNIVERSITY,
TUITION FREE. LA FAYETTE, IND.

Engineering Courses for Special Students.

The Bromfield-Pearson Technical School, of Tufts College, offers exceptional opportunities to students who wish to pursue a two years course in Engineering or who may desire to fit for the Engineering Courses of the college in one year. For information apply to

GARDNER C. ANTHONY, Dean,
Tufts College, Mass.

THE LANE & BODLEY CO.,

CINCINNATI, OHIO.

ENGINES,

ALL SIZES.
Simple and Compound
CORLISS ENGINES A SPECIALTY
HEAVY SLIDE VALVE ENGINES,
Shafting, Hangers, Pulleys, Belt Elevators, etc.

All GENUINE INGOTS & MANUFACTURES BEAR OUR REG. TRADE MARKS.

PHOSPHOR-BRONZE

INGOTS, CASTINGS, WIRE, SHEET &c.
THE PHOSPHOR BRONZE SMELTING CO. LIMITED
2200 WASHINGTON AVE., PHILADELPHIA., PA.
ORIGINAL MANUFACTURERS OF PHOSPHOR-BRONZE IN THE UNITED STATES AND SOLE MAKERS OF "ELEPHANT BRAND" PHOSPHOR-BRONZE.

STEEL CASTINGS

FROM 1 TO 40,000 POUNDS WEIGHT.
Of Open Hearth, Chester or Bessemer Steel.
True to Pattern. Sound. Solid.

GEARING OF ALL KINDS, CRANK SHAFTS, KNUCKLES FOR CAR COUPLERS.

Cross-Heads, Rockers, Piston-Heads, etc., for Locomotives. Steel Castings of Every Description.

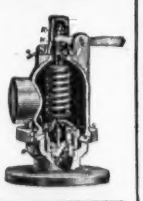
CHESTER STEEL CASTINGS CO.,
Works, Chester, Pa. Office, 407 Library St., Philadelphia, Pa.

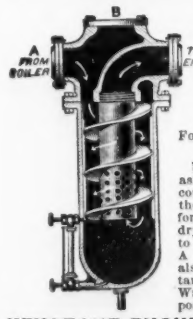
LONERGAN'S SPECIALTIES

Oil Cups for all Purposes. Sight Feed Lubricators, Pop Safety Valves, Check Valves, Water Relief Valves, etc.
"Clipper" Injectors, and other Steam Appliances.

J. E. LONERGAN & CO., 211 Race St., Phila., Pa.

CATALOGUE FREE ON APPLICATION.





DRY STEAM.

Simpson's Centrifugal Steam Separator.

For Supplying Clean and Dry Steam to Engines, Dry Houses, etc.

Place Separator as close to engine as possible, the steam taking a spiral course between the threads causes the water to be thrown by centrifugal force against the outer walls, while the dry steam goes through the small holes to center of pipe. Steam can enter at A or B, as convenience may require; also used in conveying steam long distances, for Steam Hammers, Dry Houses, Water Gas Generators, and for all purposes where Dry Steam is necessary.

KEYSTONE ENGINE & MACHINE WORKS.
Fifth and Buttonwood Streets, Philadelphia.

MOFFET PORTABLE DRILL.

UNSURPASSED AS A **REAMER.**

Will work in any position.

Weighs 42 lbs. and drills from ¾ to 2 inches diameter.

Runs with Steam —OR— Compressed Air.

Send for Circular.

Manufactured by
J. G. TIMOLAT,
89 & 91 S. Fifth Ave.,
NEW YORK.

A. & F. BROWN,

ENGINEERS, FOUNDERS & MACHINISTS.

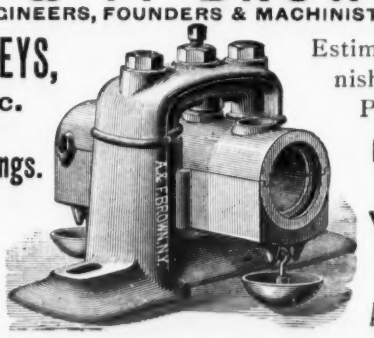
SHAFTING, PULLEYS, HANGERS, Etc.

Friction Clutch Couplings.

STEAM SIRENS, [WHISTLES].

Send for Catalogue.

17 Dey St., New York.



Estimates and Plans furnished for transmitting Power by

HORIZONTAL AND VERTICAL SHAFTING.

Also for Erecting same.

For the convenience of residents in that vicinity

WE HAVE ON EXHIBITION

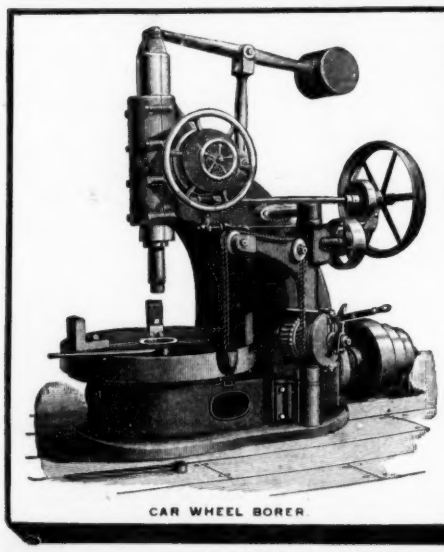
At the store of our Western Representative,

F. A. RICH, 23 South Canal St., Chicago, Ill.

No. 1 Plain Milling Machine (Screw Feed),
No. 2 Plain Milling Machine,
No. 3 Plain Milling Machine,
No. 12 Plain Milling Machine,
No. 24 Plain Milling Machine,
No. 1 Universal Milling Machine, without arm,
No. 4 Universal Milling Machine,
No. 1 Universal Grinding Machine,
No. 3 Universal Cutter and Reamer Grinder,
No. 3 Screw Machine,
No. 2 Tool-Grinding Machine,
Universal Hand Lathe,
Index Head and Centers,
Standard Reference Disks.

BROWN & SHARPE MFG. CO., Providence, R. I.

England—BUCK & HICKMAN, 280 Whitechapel Road, London, E.
Germany—SCHUCHART & SCHUTTE, 59 Spandauerstrasse, Berlin, C. (Small Tools).
Germany—G. DIECHMANN, Ansbacherstr, 5 Berlin, W. 62.
France—FENWICK FRÈRES & CO., 21 Rue Martel, Paris.
France—F. G. KREUTZBERGER, 140 Rue de Neuilly Puteaux (Seine).



CAR WHEEL BORER

MACHINE TOOLS.

Complete Equipments.

RAILROAD, CAR, LOCOMOTIVE AND GENERAL MACHINE SHOPS.

BRANCH HOUSES:
NEW YORK, CHICAGO, BOSTON, PHILADELPHIA, PITTSBURGH.

THE NILES TOOL WORKS CO.,
HAMILTON, OHIO.

Correspondence Solicited.

To Those Interested In, or Using Valves:

We have recently made improvements in the manufacture of **JENKINS BROS.' VALVES**, having increased the number of bolts, thickness of flanges, etc. We shall manufacture **ONE GRADE OF VALVE ONLY**, suitable for high or low pressure steam. The Jenkins Discs used in these valves are suitable for high or low pressure. We guarantee all valves stamped with Trade Mark.

JENKINS BROS.
New York, Boston, Philadelphia, Chicago.

BEMENT, MILES & CO., PHILADELPHIA, PA.

MANUFACTURERS OF

METAL WORKING MACHINE TOOLS

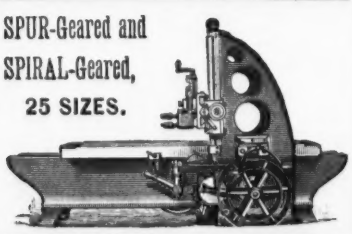
For RAILROAD SHOPS, LOCOMOTIVE AND CAR BUILDERS, MACHINE SHOPS, ROLLING MILLS, STEAM FORGES, SHIP YARDS, BOILER SHOPS, BRIDGE WORKS, ETC., ETC.

STEAM HAMMERS,

STEAM and HYDRAULIC RIVETING MACHINES.

PLANERS

SPUR-Geared and SPIRAL-Geared, 25 SIZES.



MANUFACTURED BY
The G. A. GRAY CO.,
477-483 Sycamore St., CINCINNATI, O.
New York Store, 121 LIBERTY STREET.

THE CARVIN MACHINE CO.,

Manufacturers of and Dealers in

MACHINE TOOLS.

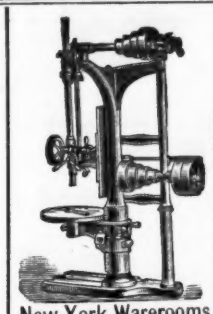
LATHES, PLANERS, SHAPERS, DRILLS, MILLING MACHINES, TURRET LATHES, GEAR CUTTERS, CUTTER GRINDERS, TAPPING MACHINES, WIRE COILING MACHINES, POWER PRESSES, HAND LATHES, PROFILERS, &c., &c.

Write for New Catalogue and List of New and Second-Hand Tools for immediate delivery.

NEW No. 3 SCREW MACHINE,
Geared Friction Head and Power Feed.

4 OTHER SIZES AND 68 VARIETIES.

LAIGHT and CANAL STS., New York City, N. Y., also 51 NORTH 7th ST., Philadelphia, Pa.



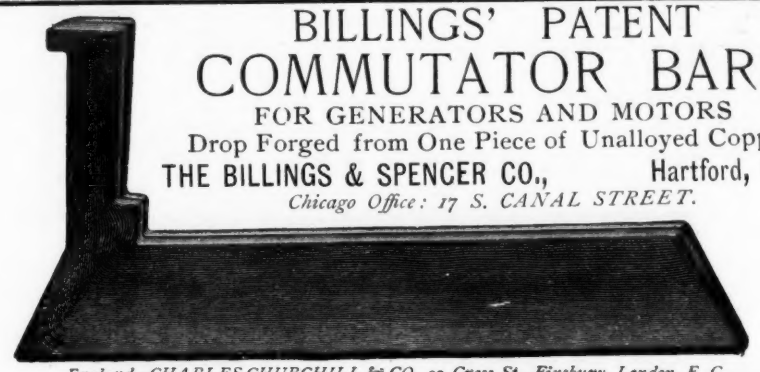
THE PRATT & WHITNEY CO.

Hartford, Conn.,

MANUFACTURE

Renshaw's Ratchet Drills, Nos. 1 and 3; **Upright Self-Feeding Hand Drilling Machines** for Blacksmiths; **Upright Drilling Machines,** single and multi-spindle, both those in which the spindles are without feed movement and tables are operated by hand or foot lever, and those in which the tables have provision for adjustment, and spindles are fed by hand lever, or by hand wheel, or automatically; also, **Horizontal Drilling Machines,** single and multi-spindle.

New York Warerooms: 136-138 Liberty St. Western Branch: 98 Washington St., Chicago, Ill.



BILLINGS' PATENT COMMUTATOR BARS

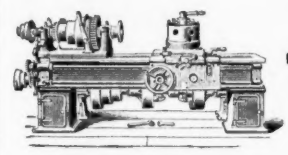
FOR GENERATORS AND MOTORS

Drop Forged from One Piece of Unalloyed Copper.

THE BILLINGS & SPENCER CO., Hartford, Conn.

Chicago Office: 17 S. CANAL STREET.

England—CHARLES CHURCHILL & CO., 23 Cross St., Finsbury, London, E. C.
France—L. ROFFO, 58 Boulevarde Richard Lenoir, Paris. *Russia—J. BLOCK, Moscow.*



WARNER & SWASEY,

CLEVELAND, OHIO.

MANUFACTURERS OF

TURRET ENGINE LATHES.

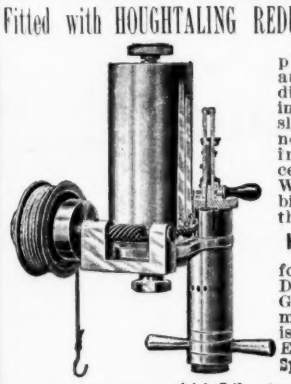
IRON AND BRASS WORKING MACHINERY.

SEND FOR ILLUSTRATED CATALOGUE.

GEO. W. FIFIELD,

Manufacturer of ENGINE LATHES from 17 to 60 in. swing. Cuts, Photographs and Prices furnished on application.

Lowell, Mass., U. S. A.



The Ashcroft Manufacturing Co.,

SOLE MANUFACTURERS OF

The Tabor Steam Engine Indicator,

Fitted with HOUGHTALING REDUCING MOTION.

The most Complete, Compact, and Reliable Indicator Outfit, for indicating high or slow speed engines now made. This instrument received at "The World's Columbian Exposition" the

Highest Award

for Excellence of Design, Superior Grade of Workmanship and Finish, Reliability and Efficiency. Send for Special Pamphlet.

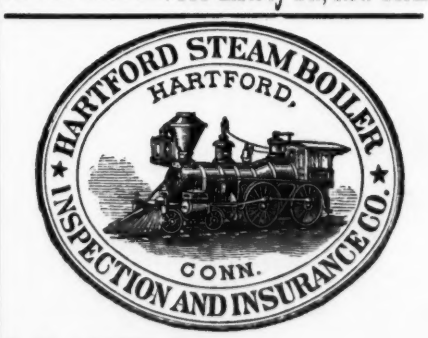
Office and Salesroom, 111 Liberty St., New York.

UPRIGHT DRILLS,

CUTTING-OFF MACHINES,
KEY-SEATING MACHINES
AND
SPECIAL MACHINERY.

Write for Catalogue and Prices.

THE W. P. DAVIS MACHINE CO.,
ROCHESTER, N. Y.



HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN.

J. M. ALLEN, President
WM. B. FRANKLIN, Vice-President.
F. B. ALLEN, Second Vice-President.
J. B. Pierce, Secretary & Treasurer.

WYMAN & GORDON
WORCESTER, MASS.
DROP FORGINGS
— WOOD WORKERS' VISES —

THE ACME MACHINERY CO.

CLEVELAND, OHIO.

Manufacturers of

ACME BOLT & RIVET HEADERS,

Acme Single and Double Automatic BOLT CUTTERS.

Cutting from 1-8 in. to 6 in. diameter.

Also SEPARATE HEADS and DIES.

MACHINE TOOLS AT REDUCED PRICES.

In order to reduce our stock, we offer 16", 18", 21" and 24" engine lathes, 16", 22", 24" and 27" planers, 10", 12" and 15" speed lathes, 15" and 20" turret lathes, at a good discount from former prices.

We also have a few 16" and 18" second-hand engine lathes, in good order, and of our own make.

THE HENDEY MACHINE CO., Torrington, Conn.

J.M. CARPENTER
PAWTUCKET, R.I.

Manufacturer —of— TAPS & DIES